

APPLICATION OF SULFUR
DYES ON COTTON AT
HIGH TEMPERATURE

WILLIAM ARTHUR MURAUSKAS

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A THESIS

**Presented to
the Faculty of the Graduate Division
Georgia Institute of Technology**

**In Partial Fulfillment
of the Requirements for the Degree
Master of Science in Textile Engineering**

**By
William Arthur Murauskas
June 1954**

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Introduction

The purpose of this study is to investigate the effects of the proposed system on the performance of the system. The study is divided into two main parts: a theoretical part and an experimental part. The theoretical part is divided into two sub-parts: a review of the literature and a theoretical analysis. The experimental part is divided into two sub-parts: a description of the experimental setup and a description of the experimental results. The theoretical analysis is based on the principles of the proposed system and the results of the literature review. The experimental results are based on the results of the experimental setup and the results of the theoretical analysis. The results of the study show that the proposed system has a significant effect on the performance of the system. The results also show that the proposed system is more efficient than the existing systems. The results of the study are discussed in the conclusion and the future work is suggested.

TABLE OF CONTENTS

	Page
ACKNOWLEDGMENTS	11
LIST OF TABLES	1v
LIST OF ILLUSTRATIONS	vi
SUMMARY	vii
 CHAPTER	
I. INTRODUCTION	1
The Sulfur Dye	
The High Temperature Theory	
The Problem	
Literature Survey	
II. INSTRUMENTATION AND EQUIPMENT	14
III. PROCEDURE	19
Characterization of the Yarn	
Scouring	
Sample Preparation	
Colorimetry	
Dyeing	
Dyed Yarn Strength	
Light-Fastness Tests	
Wash-Fastness Tests	
IV. DISCUSSION OF RESULTS	32
V. CONCLUSIONS	42
VI. RECOMMENDATIONS	44
APPENDIX	45
BIBLIOGRAPHY	75

CONTINUED ON REVERSE

101	.....	.....
102	.....	.....
103	.....	.....
104	.....	.....
105	.....	.....
106	.....	.....
107	.....	.....
108	.....	.....
109	.....	.....
110	.....	.....
111	.....	.....
112	.....	.....
113	.....	.....
114	.....	.....
115	.....	.....
116	.....	.....
117	.....	.....
118	.....	.....
119	.....	.....
120	.....	.....
121	.....	.....
122	.....	.....
123	.....	.....
124	.....	.....
125	.....	.....
126	.....	.....
127	.....	.....
128	.....	.....
129	.....	.....
130	.....	.....
131	.....	.....
132	.....	.....
133	.....	.....
134	.....	.....
135	.....	.....
136	.....	.....
137	.....	.....
138	.....	.....
139	.....	.....
140	.....	.....
141	.....	.....
142	.....	.....
143	.....	.....
144	.....	.....
145	.....	.....
146	.....	.....
147	.....	.....
148	.....	.....
149	.....	.....
150	.....	.....

LIST OF TABLES

Table	Page
1. List of Dyes Used	33
2. Dyeing Cycle Analysis of Sulfogene Carbon HCF Grains	34
3. Comparison of Dyebath Exhaustions for Sulfogene Carbon HCF Grains	35
4. Comparison of Dyebath Exhaustions for Sulfogene Navy Blue 4RCF Supra	36
5. Comparison of Dyebath Exhaustions for Sulfogene Tan 2RCF	37
6. Comparison of Dyebath Exhaustions for Sulfogene Direct Blue HRCF Conc. 200%	38
7. Comparison of Dyebath Exhaustions for Sulfogene Brilliant Green GCF Extra Conc. 150%	39
8. Yarn Number of Scoured, Undyed Cotton Yarn	46
9. Twist of Scoured, Undyed Cotton Yarn	47
10. Single Strand Breaking Strength of Scoured, Undyed Cotton Yarn	48
11. Light Absorption Percentages for Sulfogene Carbon HCF Grains	49
12. Light Absorption Percentages for Sulfogene Navy Blue 4RCF Supra	50
13. Light Absorption Percentages for Sulfogene Tan 2RCF	51
14. Light Absorption Percentages for Sulfogene Direct Blue HRCF Conc. 200%	52
15. Light Absorption Percentages for Sulfogene Brilliant Green GCF Extra Conc. 150%	53

CHAPTER 10

Page	Page
101	101
102	102
103	103
104	104
105	105
106	106
107	107
108	108
109	109
110	110
111	111
112	112
113	113
114	114
115	115
116	116
117	117
118	118
119	119
120	120
121	121
122	122
123	123
124	124
125	125
126	126
127	127
128	128
129	129
130	130
131	131
132	132
133	133
134	134
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136	136
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138	138
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169	169
170	170
171	171
172	172
173	173
174	174
175	175
176	176
177	177
178	178
179	179
180	180
181	181
182	182
183	183
184	184
185	185
186	186
187	187
188	188
189	189
190	190
191	191
192	192
193	193
194	194
195	195
196	196
197	197
198	198
199	199
200	200

Table	Page
16. Light Transmission Percentages for Sulfogene Carbon HCF Grains	54
17. Light Transmission Percentages for Sulfogene Navy Blue 4RCF Supra	56
18. Light Transmission Percentages for Sulfogene Tan 2RCF	58
19. Light Transmission Percentages for Sulfogene Direct Blue BRCF Conc. 200%	60
20. Light Transmission Percentages for Sulfogene Brilliant Green GCF Extra Conc. 200%	62
21. Dyebath Exhaustion for Sulfogene Carbon HCF Grains at 190° F. for Sixty Minutes	64
22. Dyebath Exhaustion for Sulfogene Carbon HCF Grains at High Temperature	65
23. Dyebath Exhaustion for Sulfogene Navy Blue 4RCF Supra at 190° F. for Sixty Minutes	66
24. Dyebath Exhaustion for Sulfogene Navy Blue 4RCF Supra at High Temperature	67
25. Dyebath Exhaustion for Sulfogene Tan 2RCF at 190° F. for Sixty Minutes	68
26. Dyebath Exhaustion for Sulfogene Tan 2RCF at High Temperature	69
27. Dyebath Exhaustion for Sulfogene Direct Blue BRCF Conc. 200% at 190° F. for Sixty Minutes	70
28. Dyebath Exhaustion for Sulfogene Direct Blue BRCF Conc. 200% at High Temperature	71
29. Dyebath Exhaustion for Sulfogene Brilliant Green GCF Extra Conc. 150% at 190° F. for Sixty Minutes	72
30. Dyebath Exhaustion for Sulfogene Brilliant Green GCF Extra Conc. 150% at High Temperature	73
31. Comparison of Residual Strengths of Dyed Yarns	74

LIST OF ILLUSTRATIONS

Figure	Page
1. Morton One-Pound Package Machine (Modified), Top View	16
2. Morton One-Pound Package Machine (Modified), Side View	17
3. Lunetron Colorimeter, Model 402-E	18
4. Sulfogene Carbon HCF Grains Graph of Concentration vs. Percentage Light Transmission	55
5. Sulfogene Navy Blue 4RCF Supra Graph of Concentration vs. Percentage Light Transmission	57
6. Sulfogene Tan 2RCF Graph of Concentration vs. Percentage Light Transmission	59
7. Sulfogene Direct Blue 8RCF Conc. 200% Graph of Concentration vs. Percentage Light Transmission	61
8. Sulfogene Brilliant Green GCF Extra Conc. 150% Graph of Concentration vs. Percentage Light Transmission	63

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11	DECLARATION OF WORK - 11/11/11	11
12	DECLARATION OF WORK - 11/11/11	12
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98	DECLARATION OF WORK - 11/11/11	98
99	DECLARATION OF WORK - 11/11/11	99
100	DECLARATION OF WORK - 11/11/11	100

APPLICATION OF SULFUR DYES
ON COTTON
AT HIGH TEMPERATURE

SUMMARY

The purpose of this investigation was twofold. The first, and more general, aim was to contribute, in some small measure, to the knowledge of dyeing by determining what benefits, if any, can be realized from the high temperature technique in applying sulfur dyes to cotton. In this instance, it is considered that even negative information will be of considerable value if only by virtue of the fact that the question must be answered if the field of high temperature is to be explored thoroughly. The second, and more specific, aim was to determine whether industry can utilize profitably the high temperature method in applying sulfur dyes to cotton with no more special equipment than the pressure-closed dyeing systems that it already has at its disposal. In this instance, only positive information is of value.

During the dyeing phase of this work, dye-house-like conditions were maintained in preference to laboratory conditions to satisfy the above-mentioned second aim. The dyeings were performed in a Norton one-pound package machine,

modified to permit utilization of the entire dyebath at the high temperature rather than only about half the dyebath, as was the case prior to modification.

Five sulfur dyes, representative of the ranges of light-fastness and wash-fastness available to this class, were selected for use in the problem. Four one-pound packages of cotton yarn were dyed with each color; two runs being made at a normal temperature of 190° F.; and two runs being made at a high temperature of 250° F., under sufficiently controlled conditions to provide a basis for comparison. A preliminary high temperature run was made to determine the optimum duration of the high temperature phase of the dyeing. All subsequent high temperature runs were conducted in accordance with this determination. The normal temperature runs were conducted, insofar as was practicable, in accordance with the procedures recommended by the manufacturer of the dyestuffs.

The results of the two techniques were compared, for each dye, on the following bases:

- (1) the duration of the dyeing cycle
- (2) the exhaustion of the dyebath
- (3) light-fastness
- (4) wash-fastness
- (5) the residual strength of the dyed yarn.

In every case, the high temperature technique proved superior to the normal temperature method both in the

duration of dyeing cycle and in exhaustion of the dyebath. No significant sacrifice of light-fastness, wash-fastness, or yarn strength was experienced.

The most valued finding of this thesis is the fact that certainly equal, and, in many cases, better, dyeing results can be obtained through the use of high temperature techniques at a thirty-three per cent saving in time.

The wide range of variation between the performances of the individual dyes points to the possibility that some members of this class may not be applied profitably at a high temperature. Extensive research efforts on the part of individuals throughout the world have established the value of the high temperature technique sufficiently well to warrant wide-scope research on the part of the dyestuff manufacturers into the adaptability of each of their dyes to application at a high temperature. It is suggested that such information be put at the disposal of the dyeing industry, so that those who are able to could avail themselves of the economies and other benefits to be realized from the use of high temperatures.

The first of these is the fact that the system is not
 as simple as it appears to be. It is a complex system
 which involves many different factors. The second is
 the fact that the system is not as well understood
 as it appears to be. There are many different
 theories about the system, and it is not clear
 which one is correct. The third is the fact that
 the system is not as stable as it appears to be.
 It is subject to many different influences, and
 it is not clear how these influences affect the
 system. The fourth is the fact that the system
 is not as predictable as it appears to be. It
 is subject to many different uncertainties, and
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 is not as efficient as it appears to be. It
 is subject to many different inefficiencies, and
 it is not clear how these inefficiencies affect the
 system. The seventh is the fact that the system
 is not as reliable as it appears to be. It
 is subject to many different failures, and it is
 not clear how these failures affect the system.

CHAPTER I

INTRODUCTION

The year 1873 marked the inception of sulfur dyes when two inspired Frenchmen, Croissant and Bretonniere, giving full reign to their imaginations and hopes, melted sulfur and sodium sulfide together with sawdust, blood, peat, and other "organic substances" to come up with a successful coloring matter which they proceeded to name "Cachou de Laval". The connection with 'Laval' is not known, but the word, 'Cachou', goes back to the Malayan word, 'catechu', which refers to various products of particular tropical plants which were used for dyeing, tanning, and even for preserving fish nets. In view of the foregoing, it is easy to understand the inability of either Croissant or Bretonniere to produce a satisfactory description of the exact chemical constitution of their end product. Unfortunately, this stigma of uncertainty has plagued the sulfur dye throughout its history, even to the present day.

It is only fair to say, however, that a good deal of the mystery has been cleared away as far as the modern sulfur dye is concerned. The work started only twenty years after Croissant and Bretonniere's experiment when, in 1893, Vidal,

1. Introduction

2. Background

The purpose of this study is to investigate the effects of the proposed system on the performance of the system.

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another Frenchman, melted sulfur and sodium sulfide together with intermediates of known chemical constitution, para aminophenol and dinitrophenol, to produce a black sulfur dye of immediate success, appropriately named, "Vidal's Black". Using such intermediates of known chemical constitution, of course, equips the experienced chemist with considerably more information on which to base an opinion as to the constitution of the end product. Work has progressed at length to the point where, in current times, the chemical constitution, and even the structure, of the building units of sulfur dyes is known. But the arrangement of these units in the dye structure and the exact number that go to make up a complete molecule are still matters which have not been determined with requisite scientific accuracy.

The entire difficulty in the matter stems from the fact that sulfur dyes, at best, are mixtures of products of the original members of the reaction. The sulfur dyestuff, itself, which would be the chief coloring agent in the mixture, is extremely difficult to isolate. As it approaches purity, it becomes less and less soluble, even in the alkali sulfide solutions normally used to dissolve the dyes.

The sulfur dye's indifference to chemical analysis, however, has not detracted from its long-standing success and popularity. Though the full range of colors is not available in the sulfur dyes, and though the colors that are available produce far from brilliant shades, the cheapness of the dye

and its generally good fastness to light, washing, and crocking have made it a natural choice for heavy cotton fabrics, industrial fabrics, and work clothing. For years, the dye-stuff industry has produced more sulfur blacks than any other dye, and, to this day, they stand among the top three or four dyes in production.

In recent years, sulfur dyes have lost a share of their original popularity to newer, or improved, competitive products. However, the development of a dyeing technique which would improve upon the efficiency of present methods could do much to bolster the status of what is, essentially, a good dye handicapped with poor exhaustion properties.

The most important recent development in the field of dyeing textiles, the high temperature technique, could offer some promise for this class of dyes. It has already led to signal success in applying colors to the "hard-to-dye" synthetics, and it greatly speeds the dyeing of wool (1). The whole science of dyeing is based almost solely on empirical knowledge. If all the benefits to be gained from the use of the high temperature technique are to be realized, then the fund of the empirical knowledge of dyeing must be enlarged to include the various effects of high temperatures on all dyes and fibers in their usual combinations. This work is intended to supply some of that information for the sulfur dyes and the cotton combination.

High temperatures work to advantage in many dyeing operations through various mechanisms, all stemming from the

thermal energy increase of the fiber-dyebath system. For the fiber, the additional heat aids in swelling the mass, thus serving to enlarge the macro-molecular interstices. This, of course, provides easier entry for the dye molecule, or aggregate, into the interior of the fiber.

As for the dyes, very few are known to go into complete solution at room temperature in the usual dyebath concentrations. Instead, they tend to form aggregates of anywhere up to one hundred molecules, depending upon the nature of the particular dyestuff under consideration. This works to no advantage in the dyeing operation. The dye molecules, themselves, are characteristically large in structure, often approaching the interstices of the fiber in size. Common aggregations of these massive molecules can, and often do, exceed the size of the interstices. Good dyeing cannot be realized if the dye particles are too large to enter into the interior of the fiber.

However, it is also known that an increase in the temperature or an extreme dilution of the solution will act to break down these aggregates. Since a very dilute solution does not serve as a good working dyebath, the only practical way to reduce the degree of aggregation of the dye is to raise the temperature of the bath. Some dyes will disperse satisfactorily at, or below, the boiling temperature. Others will not. Most dispersions can be improved by raising the temperature above the boil.

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High temperature also increases the migratory activity of the dye particles. This causes earlier and better penetration of the fiber by the dye. It also encourages better levelling of the deposited color. A dye, by its own definition, must have a characteristic affinity for its fiber. It derives its affinity from hydrogen bonding or residual valences. Rarely do a dye and a fiber combine chemically in the common sense of the word. Under normal conditions, remembering that they never lose their tendency to aggregate, the dye particles often accumulate on selected areas of the goods at the expense of more lightly laden areas. Under higher temperatures, this tendency merely to aggregate on the fiber is counteracted by the higher kinetic energy generated by the heat. The dye particles which would be in excess in any one area receive sufficient motive force to migrate to a more sparsely laden area where the opportunity for permanent bonding with the fiber is much greater. The end result is better levelling of the color.

The problem at hand was to determine whether these high temperature principles can be applied profitably to the dyeing of cotton with sulfur dyes. To be profitable, the operation must save either time or material.

Normally, sulfur dyes do not exhaust well. The cotton preferentially absorbs only twenty to thirty per cent of the dyestuff from the bath. For economy's sake, the one bath must be used for several runs, with periodic replenishment

of the exhausted dye increment. This cannot be continued indefinitely, though. The dye does age on standing, and will lose some of its coloring strength as a consequence. Eventually, the standing bath must be replaced with an entirely fresh one. If the exhaustion of the dyebath could be increased, then, literally, less material and money would go down the drain.

Even more important than the saving of material, since sulfur dyes are relatively cheap, is the saving of time. Time, in a profit and loss statement of operation, becomes translated into terms of labor and effective employment of equipment. Both items are commonly among the most expensive in most enterprises. If three high temperature dyeing runs could be completed in the time that it normally takes to do two normal temperature runs, then, in effect, the production capacity of the plant would be increased automatically by fifty per cent without the addition of a single piece of equipment.

All savings are to no avail, however, if the high temperature product is not as good as the normal temperature product. The best gages for comparison are fastness to light and washing, and residual strength of the yarn. None should suffer damage from the higher temperature. Or, at least, no damage should be so extensive as to offset any benefits to be gained.

Unfortunately, we are illy equipped to engage in theoretical conjecture on this matter. Though we are learning fast, too little is now known about the physico-chemical properties of dyes and their fibers. The enigma of the sulfur dye's chemical structure makes the problem even more complex in this case. Venkataraman (2) nicely implies the futility of any attempt at prediction when he states,

On the theoretical side, curiously enough, color chemistry is almost a virgin field. Our knowledge of the relation between the chemical constitution of dyes and their color is largely empirical. The physicists have not yet been able to proceed beyond a few hydrocarbons in their application of quantum mechanical methods to the interpretation and prediction of absorption spectra. Little is known of the precise action of light on dyes when fading takes place, and of any relation between the color and the chemical constitution of a dye on the one hand and its fastness to light on the other. Concerning the catalytic activity of certain dyes in the photo-chemical degradation of cellulose, several problems remain unsolved. The theories of dyeing are in an extremely rudimentary condition, notwithstanding the spate of publications on the subject from time to time.

Moreover, the sulfur dyes are a family only by virtue of their common method of preparation, that is, the fusing together of various organic intermediates with sulfur, sodium sulfide, and/or polysulfides (3). It is not reasonable to expect that any one member will represent the behavior of the entire family.

In view of the foregoing, only one course of action remained open. The empirical method was the only attack which could yield sufficiently concrete answers for the solution of this problem. Any theorizing was beyond its scope

and will be left for the time when our knowledge of sulfur dyes and the chemistry of dyeing is less sketchy than it is at present.

The most thorough treatment of the theory of high temperature dyeing is that done by Drijvers (4), and his will be the guiding principles in the handling of this problem. The following is a review of these principles.

Dyeing can be considered to be a physico-chemical, or a purely chemical, reaction. This reaction is reversible, and will reach an equilibrium eventually. The state of the equilibrium and the time within which it is established are functions of the temperature under which the reaction is carried out.

There are three phases involved in the dyeing cycle. The first is the partial diffusion of the dyestuff in the bath toward the surface of the fiber. The dye molecules, by virtue of their residual valences, also tend to aggregate together in the dyebath. The degree of aggregation differs from one dyestuff to another. For each temperature, there is a corresponding state of equilibrium between the quantity of dye in the molecular state and the quantity of dye in the aggregated state.

The second phase is the adsorption of the dye by the fiber. The molecularly diffused dye is brought into contact with the fiber by the circulating bath. The adsorption

phenomenon proceeds up to the point of the equilibrium that corresponds to the particular temperature prevailing.

The third phase is the diffusion of the dye into the interior of the fiber. The dye molecule must penetrate the intercrystalline spaces of the cellulose macro-molecule. Penetration, normally, is slow and difficult because of the mechanical resistance which the dye meets in progressing through the fiber. Consequently, the dye piles up and rapidly accumulates on the surface of the fiber, hastening the state of equilibrium. As a result, adsorption stops, but diffusion into the interior of the fiber is encouraged. High temperature greatly aids in the penetration process. The addition of electrolytes does encourage an early arrival at the state of physico-chemical equilibrium, but temperature still remains as the primary determinant.

A dynamic system of a dyebath and a mass to be dyed cannot be driven toward practical exhaustion until a tinctorial equilibrium has been reached between the entire mass and the whole of the dyebath. This consideration is of prime importance to level dyeing. The principal factors having the power to influence this system are temperature and concentration of electrolyte. The temperature most importantly influences the speed with which dynamic equilibrium is reached. The manner by which equilibrium is reached, the quantity of dyestuff, and the amount of material to be dyed in its presence at the moment of equilibrium are characteristics belonging to each individual dye.

Practical application of these principles involves raising the temperature as rapidly as possible to the point most favorable to the speed of diffusion of the dye and to the early establishment of the physico-chemical equilibrium. This promotes good penetration and levelling. Then the bath is cooled to the point most favorable to exhaustion. The addition of electrolyte will increase this value. In essence, the technique is the reverse of the normal order of dyeing.

Perhaps the most ambitious undertaking in high temperature research was the work done by the Philadelphia Section of the American Association of Textile Chemists and Colourists (5). Their announced purpose was to investigate, briefly, the behavior of every class of dye and all the common fibers under high temperature. Their report is the only one that carries any information on sulfur dyes at high temperatures. They worked with five dyes of this class and found that a temperature of 236° F. would destroy up to five per cent of the coloring power, though in one case (Sulfogene Golden Brown RCF) improvement of five per cent was shown. They offer the opinion that the cotton fiber should be able to withstand the same temperatures and conditions of alkalinity in sulfur dyeing that it does in kier boiling.

In their actual dyeing runs, they padded cotton fabric with a solution of thirty grams per liter of dye solubilized in an equal amount of sodium sulfide. This they dried and then treated in a glass pressure tube with a one-to-ten

Individual Performance Based on Individual Improvement

There are a number of factors that can affect individual performance. These factors can be grouped into three main categories: individual factors, organizational factors, and environmental factors. Individual factors include the individual's ability, motivation, and knowledge. Organizational factors include the organization's structure, culture, and resources. Environmental factors include the individual's social and physical environment. All of these factors can have a significant impact on individual performance. Therefore, it is important to consider all of these factors when evaluating individual performance.

One of the most important factors that can affect individual performance is the individual's ability. This includes the individual's physical, mental, and emotional capabilities. The individual's ability can be affected by a number of factors, including genetics, environment, and experience.

Another important factor that can affect individual performance is the individual's motivation. This is the individual's willingness to put forth effort and achieve goals. Motivation can be affected by a number of factors, including the individual's beliefs, attitudes, and values.

Finally, the individual's knowledge is another important factor that can affect individual performance. This is the individual's understanding of the tasks and processes involved in their work. Knowledge can be affected by a number of factors, including education, training, and experience.

Organizational factors can also have a significant impact on individual performance. These factors include the organization's structure, culture, and resources. The organization's structure can affect the individual's ability to access the resources and information they need to perform their job.

The organization's culture can also affect individual performance. A positive culture can encourage the individual to put forth effort and achieve goals. A negative culture can discourage the individual from putting forth effort and achieving goals.

Finally, the organization's resources can affect individual performance. If the organization has the resources the individual needs to perform their job, they will be able to perform better. If the organization does not have the resources the individual needs, they will be unable to perform as well.

Environmental factors can also have a significant impact on individual performance. These factors include the individual's social and physical environment. A supportive social environment can encourage the individual to put forth effort and achieve goals.

A supportive physical environment can also encourage the individual to put forth effort and achieve goals. A supportive social and physical environment can help the individual to perform better and achieve their goals.

Therefore, it is important to consider all of these factors when evaluating individual performance.

fabric-to-bath ratio of seven and one-half grams per liter of sodium sulfide at a temperature of 236° F. for thirty minutes. They judged their results by a visual rating of the tinctorial strength and shade, and found an increase in strength in every case but one which did, at least, equal the results of the normal temperature run of 180° F.

The high temperature produced no change in the dyes' original fastness ratings.

They did not attempt to measure and compare bath exhaustions.

Their findings indicated that, though the tinctorial strengths of the sulfur dyeings at high temperature increased only slightly, good dyeings might be obtained by much shorter periods of exposure to the high temperature.

Among their general conclusions, they state that high temperatures greatly increase diffusion and penetration, and that speed, levelling, and diffusion gains make high temperatures worthy of adaption to high-speed, continuous dyeing processes where volume production can make the most of the economies to be gained.

Zimmerman (1), though not referring directly to sulfur dyes, does list some of the more important general aspects of high temperature dyeing.

He reports that high temperature dyeing is fifteen years old. Pressure, itself, has no effect on the process, but is used merely to arrive at temperatures above the boil.

The rates of most chemical reactions increase with temperature, and the rate of dyeing similarly increases. However, some dyes decompose when held at a high temperature for several hours. Most machines dye at 250° F. and forty pounds gage pressure. Little advantage is gained by the use of a higher temperature.

Dyeing takes place by the diffusion of dye molecules into the intercellular spaces of the fiber. Fiber swells in water. Wool, in particular, undergoes greatly increased swelling as the temperature is increased. At the same time, the rate of diffusion of the dye particles increases with temperature and with a decrease in their size. Few dyes are known to go into molecular dispersion in aqueous solutions. They commonly aggregate into groups of from two to ten molecules, sometimes as many as a hundred molecules. The degree of aggregation varies inversely with the temperature.

In summation, high temperature promotes dyeing by increasing the pore sizes in the fiber; by decreasing the size of the dye particles; and by increasing the rate of diffusion of the dye. Cellulosic materials do not respond to high temperatures as well as do protein materials. Also, under equal conditions, a fiber at equilibrium takes up less dye at higher temperatures, but the rate of diffusion of the dye is increased. In general, high temperature dyeing takes less time and produces equal or better fastness ratings in comparison with normal temperatures.

As for damage to textile fibers, none suffer significantly from exposure to high temperatures for a short period of time, with the exception of cellulose acetate.

With the exception of Drijvers' work, it appears that practically all high temperature research has been done using laboratory techniques and highly specialized equipment such as mercury column seals, pressure-differential platform valves, and high-pressure glass capsules. None of these hold great promise for economical reproduction on an industrial scale. Further, no reports have been found dealing with the specific aspects of high temperature application of sulfur dyes under simulated dye-house conditions. It is felt that this work can help to bridge the gap between laboratory and dye-house by attempting to provide answers which will reflect directly upon considerations of immediate practical application of sulfur dyes at high temperatures on a commercial basis.

CHAPTER II

INSTRUMENTATION AND EQUIPMENT

The following list comprises all the items of special equipment used in this problem:

Morton Twelve-Pound Package Machine

Morton One-Pound Package Machine (Modified)

Atlas Fade-Ometer

Atlas Launder-Ometer

Lumetron Colorimeter, Model 402-E

With the exception of the modified Morton One-Pound Package Machine, all items of equipment are standard manufacturer's products, available on the open market, and require no special descriptive treatment.

The Morton One-Pound Package Machine was modified by the addition of a stainless steel cover which can be bolted to the top of the expansion chamber. This seals the chamber from the atmosphere and permits the entire dyebath to be circulated under high temperature.

Before modification, the expansion chamber had to be closed off from the remainder of the system by means of valves whenever it was necessary to use high temperatures. Any dye solution remaining in the expansion chamber, of course, could not be used during the high temperature phase of the dyeing. This resulted in the loss of all control over

dye-bath ratios. Two views of the modified machine are shown in Figures 1 and 2.

A view of the Lametron Colorimeter, Model 402-E, is shown in Figure 3.

All other equipment are standard items commonly found in any laboratory connected with chemistry and dyeing.

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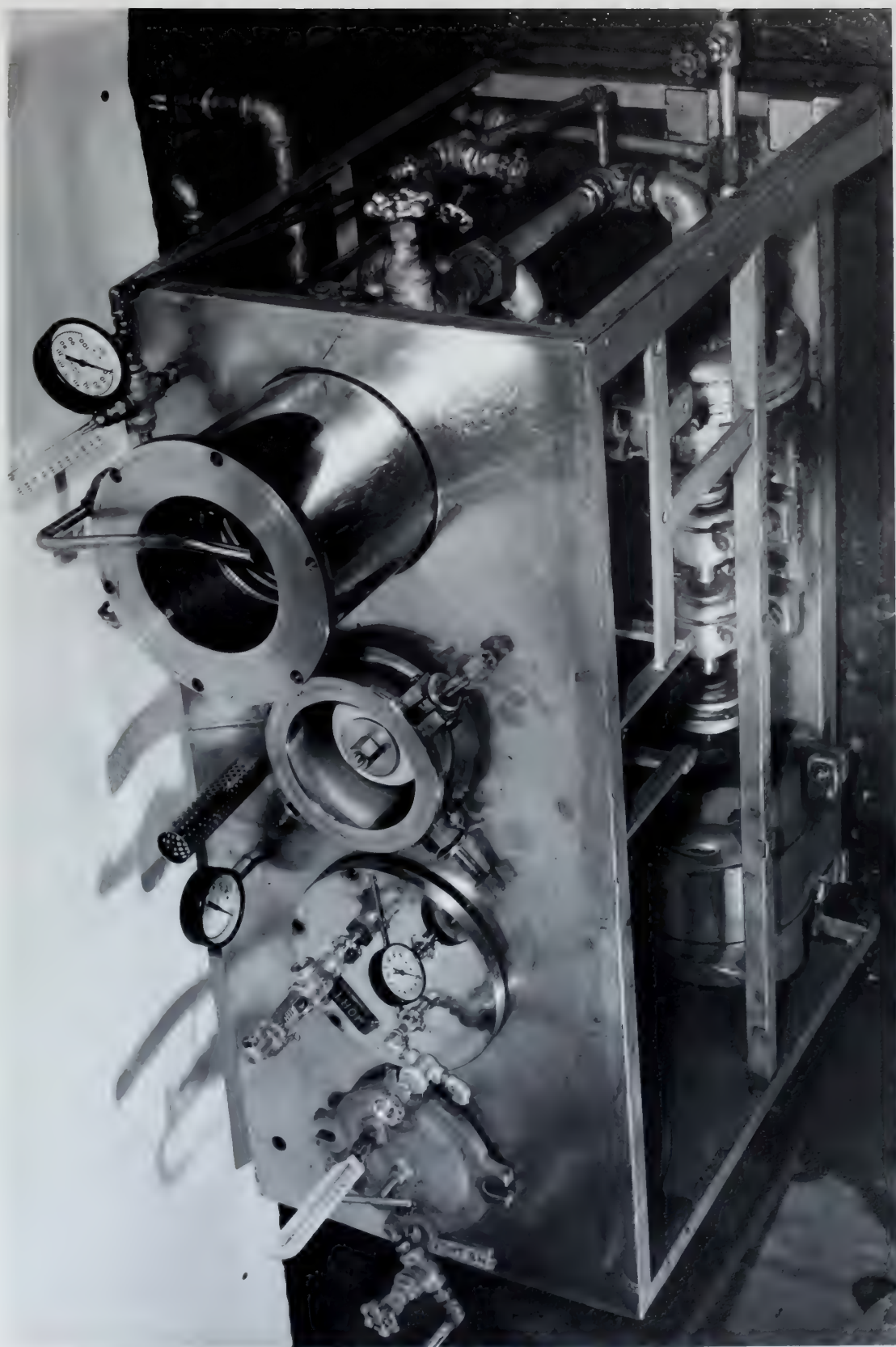


Figure 1. Morton one-pound package machine (modified)
Top View

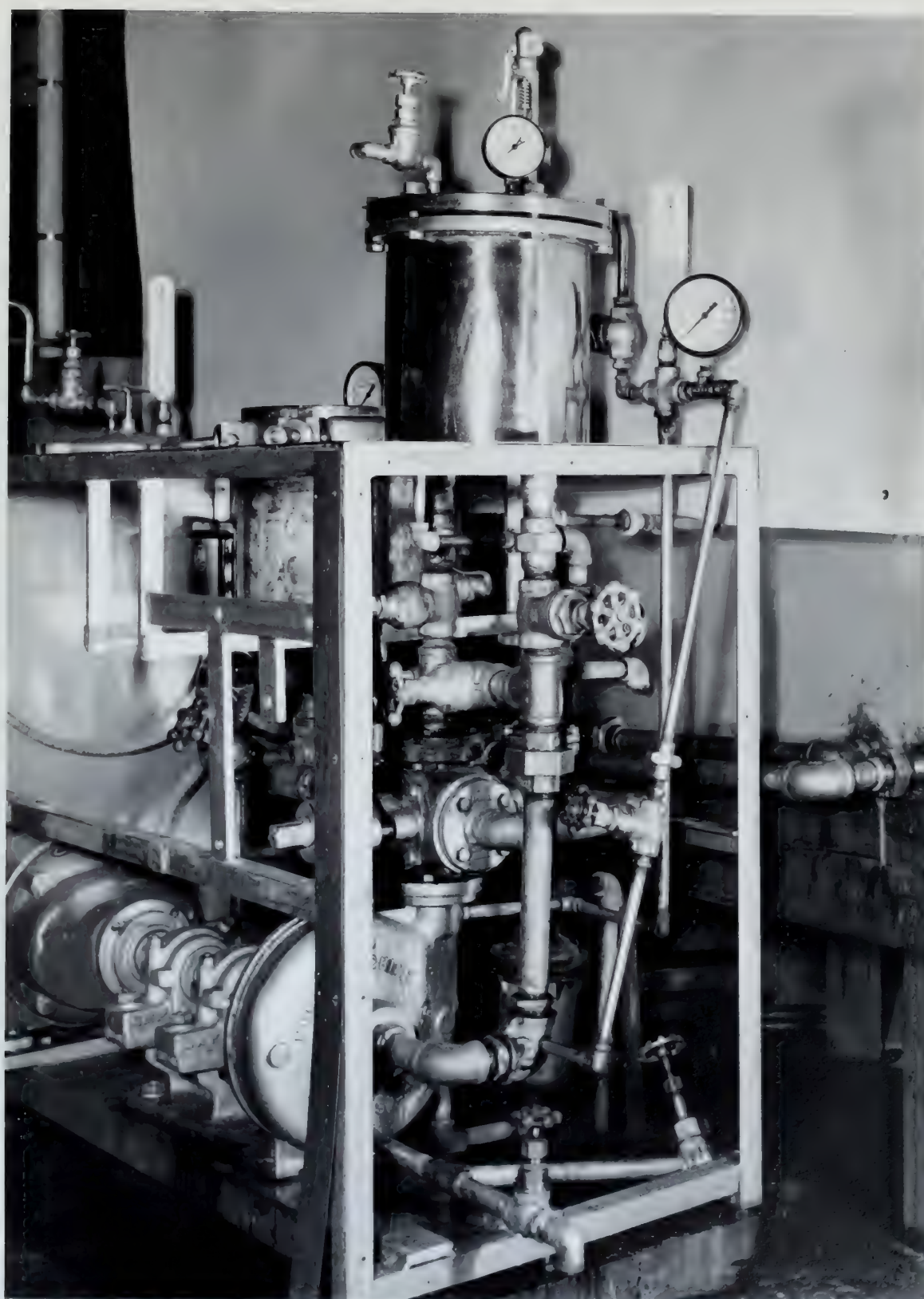


Figure 2. Morton One-pound Package Machine
(Modified), Side View



Figure 2. Lumetron Colorimeter, Model 402-7

CHAPTER III

PROCEDURE

Characterization of the Yarn.--The cotton yarn to be used in this problem was first characterized with regard to size, twist, and breaking strength in accordance with the American Society for Testing Materials Standard Test D 180-52T (6). It was found to be a number 16 single-ply yarn with a 2 twist of 18.1 turns per inch and with a breaking strength of 1.15 pounds. The strength, however, was found to be highly irregular, varying from 0.9 to 1.62 pounds. This irregularity is expected to affect the accuracy of the strength tests on the dyed samples. The results are shown in Tables 8, 9, and 10.

After characterization, the yarn was wound on perforated, stainless-steel dyeing tubes to yield around one pound, net, per package.

Scouring.--Rather than scour each package of yarn singly in the one-pound machine just prior to dyeing, the yarn was scoured in groups in the twelve-pound machine, thus saving time in the subsequent dyeing operations.

In scouring, the yarn was first wet out with one-half per cent of Tergitol Penetrant 7 at 180° F. for fifteen minutes. The bath was set, then, at 200° F., and the actual

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CONTENTS

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scouring was done in five per cent sodium hydroxide, three per cent sodium carbonate, and one per cent soap flakes for one hour. All percentages are based on the net weight of the yarn. The bath was drained, and alternate hot and cold rinses were applied until red litmus paper no longer registered alkalinity in the bath. The packages were hydro-extracted and then dried in a hot air oven for thirty-six hours. This was followed by a forty-eight hour conditioning at sixty-five per cent relative humidity and 70° F.

Sample Preparation.—Each package of scoured yarn was tagged with a number which it would carry throughout the experiment.

Eight breaking strength tests were made on each of ten packages, five of which were to be dyed at normal temperature (one for each dye used), and five to be dyed similarly at high temperature. The strength data were recorded by package number to serve as the basis for determining the comparative effects on yarn strength of each of the dyes both under normal temperature and under high temperature applications.

These data are meant to serve merely in the capacity of a control and not as an exhaustive test, inasmuch as all published literature indicates that cotton is not expected to suffer significantly from exposure to temperatures of the order to be used in this experiment (1), (5), and (7).

The weight of each package was determined to within one-tenth of a gram. This information was recorded by

package number to serve as the basis for the calculation of all weights of dyes and chemicals to be used in the processing of the packages.

Colorimetry.—Colorimetric measurements were used to determine the exhaustion of the dyebath.

Colorimetry is based on two laws (8). The first, known as Lambert's law, states that the amount of monochromatic light transmitted by a pure, colored solution is a function of the thickness of the layer of the solution through which the light is transmitted. This is expressed mathematically as,

$$I_t = I_0 \cdot e^{-al} \quad (1)$$

where I_t is the intensity of the light transmitted through the solution, I_0 is the intensity of the source light being directed into the solution, l is the thickness of the layer of solution, and a is a constant.

The second law, known as Beer's law, states that the amount of monochromatic light transmitted by a pure, colored solution is a function of the concentration of the solute, in molecular dispersion, in the solution. This is expressed mathematically as,

$$I_t = I_0 \cdot e^{-bc} \quad (2)$$

where c is the concentration of the solution, b is a constant, and the remaining symbols are the same as those named above.

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The two laws can be combined as follows:

$$I_t = I_o \cdot e^{-kcl} \quad (3)$$

where k is a constant.

Most colorimeters are best able to measure in terms of percentage transmission of light, T , expressed as,

$$T = \frac{I_t}{I_o} 100 \quad (4)$$

However, transmission does not vary linearly with concentration as does optical density, D , equated as,

$$D = \log_{10} \frac{I_o}{I_t} = \log_{10} \frac{100}{T} \quad (5)$$

This equation can be combined with (3) as follows:

$$D = kcl \quad \text{or,} \quad (6)$$

$$D = ecl \quad (7)$$

where c is expressed in moles per liter, l is expressed in centimeters, and e is the molar extinction coefficient. The extinction coefficient is equal to the optical density of a one-centimeter thick layer of a one molar solution of the particular substance under investigation.

Formula (5) is the one normally used with a colorimeter that reads in terms of percentage transmission of light. Under ideal conditions, and when plotted on a semi-logarithm paper against values of concentration of solution, it should

1. The first part of the paper is devoted to the study of the

$$f(x) = \frac{1}{x} \log \frac{1}{x}$$

for $x \in (0, 1)$. It is shown that

the function $f(x)$ is concave on $(0, 1)$ and that

the inequality $f(x) \geq 0$ holds for all $x \in (0, 1)$.

$$f(x) = \frac{1}{x} \log \frac{1}{x}$$

is a special case of the more general inequality

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yield a perfectly straight line. The ideal conditions referred to include having a perfectly monochromatic light source and a perfect molecular solution. In the work at hand, neither condition could be realized. The colorimeter used employed a tungsten filament white light source and a series of filters which transmitted a working band of light thirty millimicrons wide (fifteen millimicrons to either side of the designated wavelength). Furthermore, as had been indicated earlier, dyes are rarely known to go into perfect molecular solution, except under special conditions.

As could be expected, in trial runs with precisely controlled concentrations of dye solutions, a curve, rather than a straight line, resulted from the use of formula (5).

As a trial, values of concentration of solution were plotted against percentage transmission light readings taken directly from the dial of the colorimeter. The resulting line was no more curved than that generated by formula (5). It was found to work very well in determining the concentration of a solution from a percentage transmission of light reading. It was then decided to construct a graph for each dye in that form. See Figures 4 through 8.

The capacity of the dyeing machine, with a one-pound package of yarn installed, was accurately determined. This volume was found to be fourteen liters. It was adhered to strictly in all dyeing runs, making due allowance for the dye solution and the salt solution to be added during the run.

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A ten per cent dyeing was decided upon for all runs since this represented a maximum dyeing for sulfur dyes. This percentage on a one-pound package is fourteen liters of bath yields an initial concentration of a little more than three grams per liter. This is too dense a concentration to be read on the colorimeter. However, if the solution is diluted to one one-hundredth of its original concentration, it falls very nicely within the middle reading range of the colorimeter. This determined that the graphs would have to be constructed for a range of concentrations of from 0.050 to 0.010 gram per liter.

The calibrating solutions were prepared by weighing out, on the analytical balance, exactly one gram of dye, one gram of sodium carbonate, two grams of common salt, and from one to four grams (dependent on the dye) of crystalline sodium sulfide of reagent grade. The dye, soda ash, and sulfide were slurried with water and boiled for one minute. Three hundred milliliters of water were added and the solution was boiled for another minute. Then it was cooled to room temperature to prevent expansion when poured into the volumetric flask.

The salt was dissolved separately and then was added to the solution. The two grams of salt represent, exactly, the twenty per cent salting that each dyebath would be subjected to prior to the end of the run and the drawing of the aliquot portion sample of the dyebath for colorimetric measurement.

Sufficient water was added to the solution in the volumetric flask to make exactly one liter of solution. The solution was now an exact proportional representation of the composition of the dyebath.

Fifty milliliters of the solution were drawn with a volumetric pipette and were mixed with four hundred and fifty milliliters of water in a five hundred milliliter volumetric flask to yield a concentration of one-tenth gram per liter.

From this last as a working solution, concentrations of 0.050, 0.040, 0.030, 0.020, and 0.010 gram per liter were then prepared in a fifty milliliter volumetric flask.

This procedure of dilution was conducted to reduce the percentage of relative error to as small a value as possible.

Once the solutions were prepared, it was next necessary to determine which filter would be the most appropriate for each dye. A solution with a specific color will absorb more light of one wave length than it will of another. As an extreme example, a pure red solution will transmit one hundred per cent of a light having a pure red wavelength, regardless of its concentration. Consequently, no changes in readings could be obtained by varying the concentration of the solution. The most appropriate light is the one to which the solution will appear to be most opaque, or optically dense. The filter producing that light is the one which must be used.

With the 0.050 gram per liter concentration as the subject sample, readings were taken for each of eleven filters covering the entire spectrum of visible light. The filter yielding the least transmission, or the greatest absorption, of light was selected for use with the particular dye being measured. These absorption values are shown for each dye in Tables 11 through 15.

Next, with appropriate filter installed, readings of light transmission were taken for each of the concentrations of solution previously prepared. These values are shown for each of the dyes in Tables 16 through 20.

Graphs were constructed by plotting concentration of solution, in grams per liter, against corresponding percentage transmission of light readings. These graphs were used as the yardstick in determining the final concentration of the exhausted dyebath at the end of each dyeing run.

To prepare the dyebath samples, a portion of the bath was drawn from the dye chamber bleed-off with the bath circulating from the outside to the inside of the package. This sample was cooled to room temperature. Then one milliliter was pipetted from the sample and was mixed with tap water to fill a one hundred milliliter volumetric flask. This solution was then measured in the colorimeter.

In operating the colorimeter, one-centimeter cuvettes were used; tap water was used as a standard reference solution for the purpose of zeroing the instrument; and a sensitivity

of fifteen galvanometer graduations to ten transmission dial graduations was used.

Dyeing.--In every dyeing run, a ten per cent dye concentration, based on the weight of the yarn, was used. The dye was weighed out on an analytical balance to the thousandth of a gram. An equal weight of soda ash, and various weights of crystalline sodium sulfide of reagent grade were used as the alkaline solvents needed to drive the dye into aqueous solution. Twenty per cent salt, based on the weight of the yarn, was dissolved separately for later addition to the bath.

The dye, soda ash, and sulfide were slurried with water and were boiled one minute. The volume was brought up to five hundred milliliters with water, and was boiled for another minute.

The salt was made up into a five hundred milliliter solution with water and was heated until dissolved.

Prior to the actual dyeing run, each package was wet out with two grams of Duponol RA for fifteen minutes at 160° F. The wetting out bath was drained, and all residual wetting agent was rinsed off in a cold, running bath to prevent foaming during the dyeing run.

In the normal temperature runs, the bath, amounting to thirteen liters of water, was set at 190° F. The dye was added in two equal portions, one with the bath circulating from the inside of the package to the outside, and the other with the bath circulating from the outside of the package to

the inside. Dyeing was allowed to proceed for twenty minutes at 190° F. The direction of circulation of the bath was alternated every five minutes.

Salt was added to the bath over the following fifteen minute period, at the rate of about forty milliliters of solution every minute. The direction of circulation was alternated for each addition of salt.

Dyeing was allowed to proceed for an additional twenty-five minutes at 190° F. The direction of circulation was alternated every five minutes.

A sample of the exhausted dyebath was drawn at the end of the sixty minute dyeing cycle, to be measured for concentration in the colorimeter.

The bath was drained, and a running cold water rinse was applied until the bath ran clear.

Two hot rinses of 160° F. were run for ten minutes each. The package was then washed in one-half gram of Duponol EA at 120° F. for ten minutes.

The bath was drained, and a last running cold rinse was applied until the wetting agent foam and bubbles disappeared.

The package was removed from the machine and was hydro-extracted. It was dried in the hot air oven for twenty-four hours, and then it was conditioned at sixty-five per cent relative humidity and 70° F. for forty-eight hours.

The high temperature runs were conducted in precisely the same manner with the exception of the actual dyeing cycle. The bath was set at 190° F., and the dye was added in two equal portions, as before. The top of the expansion chamber was bolted into place and the temperature was raised to 250° F. within ten minutes.

Dyeing was allowed to proceed at 250° F. for fifteen minutes. The direction of circulation was alternated every five minutes.

The temperature was dropped to 190° F. by forced cooling. The top to the expansion chamber was removed, and salt was added in exactly the same manner as was done in the normal temperature run.

The run was terminated immediately after the fifteen minute salting phase, and a sample of the exhausted dyebath was taken for colorimetric measurement of concentration.

The remainder of the treatment was exactly the same as that for the normal temperature run.

The period of fifteen minutes for the high temperature phase was determined by a prolonged preliminary run, during which samples of the bath were taken as the temperature was being raised; while the temperature was being held at 250° F; as the temperature was being lowered; and after salt was added. The results of the run are shown in Table 2. During the high temperature phase, the best exhaustion (as indicated

by the highest transmission of light reading) was reached after twenty minutes at 250° F.

Because of the pressure on the system caused by the high temperature, the samples were tapped through a bleed-off on the temperature gage and pressure gage by-pass line. This included about one foot of tubing in which the dyebath remained stationary while the valve was closed. In consideration of this, it was felt that the readings from the tap must lag the actual condition of the dyebath by at least five minutes. Thus, a high temperature phase of fifteen minutes was selected.

A total of twenty dyeing runs were made, two for each dye at each temperature. It was felt that any one set of results was consistent enough to form the basis for a comparison.

Dyed Yarn Strength.--Eight break tests were made on each package of yarn for which breaking strengths had been recorded previously. The post-dyeing strengths were compared with the pre-dyeing strengths, and the change in strength for normal temperature dyeing was compared with the change in strength for high temperature dyeing. The results of these tests are shown in Table 31.

Light-Fastness Tests.--Light-fastness tests were conducted on the dyed yarn in accordance with the procedures described in the A.A.T.C.C. 1953 Yearbook (9). The samples, all together

in one group, were exposed to the arc-light of the Fade-Ometer for four twenty-hour increments. Fading was determined by visual inspection of the exposed sections under natural light. The first section to show appreciable change of shade determined the rating of the sample.

Wash-Fastness Tests.--Wash-Fastness Test Number Three, described in the A.A.T.C.C. 1953 Yearbook (16), was applied to knitted samples of the dyed yarn. In the test, bleached cotton sheeting was sewn to the back of the sample which measured two by four inches. The sample was sealed in a Mason Jar containing ten standard steel balls and one hundred milliliters of a standard solution of 0.5 per cent soap and 0.2 per cent soda ash. The sample was run in the Launder-Ometer for forty-five minutes at 160° F.

The sample was removed and washed twice in rinses of one hundred milliliters of water at 105° F. by shaking vigorously for one minute. Then it was soured in one hundred milliliters of a 0.05 per cent solution of acetic acid at 80° F. This was followed by a final rinse in one hundred milliliters of water at 80° F. The sample was hydro-extracted and ironed dry with the bleached cotton side up. Any running of the dye was determined by visual inspection of the bleached cotton.

CHAPTER IV

DISCUSSION OF RESULTS

Dyeing Results.—The dyes used in this experiment are listed in Table 1.

The results of the preliminary run used to determine the fifteen minute duration of the high temperature phase are shown in Table 2.

All of the normal temperature dyeing runs were sixty minutes in duration. The high temperature runs required only forty minutes to complete. This included fifteen minutes at 250° F. and fifteen minutes of salting at 190° F. The remainder of the time was used to raise and lower the temperature between these two limits. This time was a characteristic of the equipment used. It is not considered critical to the dyeing phase. It is expected that the results would be just as good if the latter time could be shortened or eliminated. This, of course, would result in an additional saving in the time required for dyeing at the higher temperature.

In every case, appreciable increase in dyebath exhaustion was experienced at the high temperature. The increase for each dye was as follows (See Tables 3 through 7):

Carbon BCF Grains	17.9%
Navy Blue 4BCF Supra	34.2%
Tan 2BCF	32.5%
Direct Blue BRCF	12.3%
Brilliant Green GCF	5.0%

THE
FEDERAL BUREAU OF INVESTIGATION
UNITED STATES DEPARTMENT OF JUSTICE

Report of Special Agent in Charge, New York Office, dated 10/10/50, captioned as above.

Re: [redacted]

Reference is made to New York Office letter to Bureau dated 10/10/50.

The following information was obtained from the New York Office files:

On 10/10/50, [redacted]

Special Agent in Charge, New York Office, advised that [redacted]

On 10/10/50, [redacted]

On 10/10/50, [redacted]

On 10/10/50, [redacted]

On 10/10/50, [redacted]

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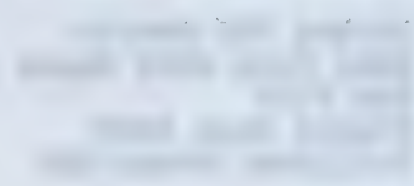


Table 1. List of Dyes Used

Sulfur Dye	Light Fastness Rating	Wash Fastness Rating
Sulfogene Carbon NCF Grains	7-8	5
Sulfogene Navy Blue 4RCF Supra	4	4-5
Sulfogene Tan 2RCF	3	4-5
Sulfogene Direct Blue BRCF Conc. 200%	5-6	4-5
Sulfogene Brilliant Green GCF Extra Conc. 150%	4-5	1

Dye Manufacturer: I. E. duPont de Nemours and Company, Inc.

Table 1. Summary of the results of the analysis.

Variable	Mean	Standard deviation
Age	34.2	10.5
Gender	0.5	0.5
Education	0.5	0.5
Income	0.5	0.5
Health status	0.5	0.5
Life satisfaction	0.5	0.5

Age, gender, education, income, health status, and life satisfaction were all significantly correlated with the dependent variable.

Table 2. Dyeing Cycle Analysis of Sulfogent Carbon RCF Grains

Time (Minutes)	Temperature (Degrees, F.)	Dyeing Phase	Transmission of Light
0	190	Enter Dye	51.0 %
5	200	Raise Temp.	51.7
8	210	"	53.1
14	220	"	52.9
21	230	"	54.9
23	240	"	53.6
33	250	High Temp.	54.0
34	250	"	54.0
35	250	"	53.8
36	250	"	53.5
37	250	"	54.1
38	250	"	54.2
43	250	"	54.9
48	250	"	55.4
53	250	"	56.3
63	250	"	56.3
67	240	Lower Temp.	55.4
74	230	"	56.7
80	220	"	57.8
85	200	Salt	59.5
108	160	Termination	62.0

Constitution of Dyebath:

Weight of Yarn (Package Number 27)	428.2	grams
Weight of Dye	42.82	grams
Weight of Sodium Carbonate	42.82	grams
Weight of Crystalline Sodium Sulfide	85.64	grams
Weight of Sodium Chloride	8.56	grams
Volume of Dyebath	14.	liters
Concentration of Dyebath	3.059	gms/L

**Table 3. Comparison of Dyebath Exhaustions for
Sulfogene Carbon NCF Grains**

Average Exhaustion of High Temperature Dyebaths	44.7 %
Average Exhaustion of Normal Temperature Dyebaths	37.9 %
Gain in Exhaustion by Use of High Temperature	6.8 %
Relative Percentage Improvement by Use of High Temperature	17.9 %
Time of Normal Temperature Dyeing Cycle	60 mins.
Time of High Temperature Dyeing Cycle	40 mins.
Gain in Time by Use of High Temperature	20 mins.
Percentage Gain in Time by Use of High Temperature	33 %

**Table 4. Comparison of Dyebath Exhaustions for
Sulfogene Navy Blue 4RCP Supra**

Average Exhaustion of High Temperature Dyebaths	34.9 %
Average Exhaustion of Normal Temperature Dyebaths	26.0 %
Gain in Exhaustion by Use of High Temperature	8.9 %
Relative Percentage Improvement by Use of High Temperature	34.2 %
Time of Normal Temperature Dyeing Cycle	60 mins.
Time of High Temperature Dyeing Cycle	40 mins.
Gain in Time by Use of High Temperature	20 mins.
Percentage Gain in Time by Use of High Temperature	33 %

**Table 5. Comparison of Dyebath Exhaustions for
Sulfogene Tan 2RCP**

Average Exhaustion of High Temperature Dyebaths	46.65 %
Average Exhaustion of Normal Temperature Dyebaths	35.2 %
Gain in Exhaustion by Use of High Temperature	11.45 %
Relative Percentage Improvement by Use of High Temperature	32.5 %
Time of Normal Temperature Cycle	60 mins.
Time of High Temperature Cycle	40 mins.
Gain in Time by Use of High Temperature	20 mins.
Percentage Gain in Time by Use of High Temperature	33 %

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**Table 6. Comparison of Dyebath Exhaustions for
Sulfogene Direct Blue BR1F Conc. 200%**

Average Exhaustion of High Temperature Dyebaths	35.6 %
Average Exhaustion of Normal Temperature Dyebaths	31.7 %
Gain in Exhaustion by Use of High Temperature	3.9 %
Relative Percentage Improvement by Use of High Temperature	12.3 %
Time of Normal Temperature Dyeing Cycle	60 mins.
Time of High Temperature Dyeing Cycle	40 mins.
Gain in Time by Use of High Temperature	20 mins.
Percentage Gain in Time by Use of High Temperature	33 %

**Table 7. Comparison of Dyebath Exhaustions for Sulfogens
Brilliant Green GCF Extra Conc. 150%**

Average Exhaustion of High Temperature Dyebaths	46.0 %
Average Exhaustion of Normal Temperature Dyebaths	43.8 %
Gain in Exhaustion by Use of High Temperature	2.2 %
Relative Percentage Improvement by Use of High Temperature	5.0 %
Time of Normal Temperature Dyeing Cycle	60 mins.
Time of High Temperature Dyeing Cycle	40 mins.
Gain in Time by Use of High Temperature	20 mins.
Percentage Gain in Time by Use of High Temperature	33 %

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The shades of the high temperature products were at least equal to those of the normal temperature products. In some cases they were slightly heavier, or darker, to a barely noticeable measure. In the case of the Brilliant Green, the high temperature products had a distinctly bluer chroma. The Tan dye produced a greener, or olive, cast at high temperature, in contrast to the redder or yellower chroma of the normal temperature product. The other dyes produced the same color at both temperatures.

An effort was made to compare the penetrations of the dyes by means of microscopic cross-sections. The thinnest cross-sectional slice that could be made with the equipment on hand was two and one-half microns. The dye was too dense, even in that thin a cross-section, to transmit sufficient working light for microscopic inspection. The only general conclusion that can be drawn is that at least good penetration was obtained.

Light-Fastness Results.--All of the dyes broke within sixty hours. For each dye, the high temperature and normal temperature products broke at exactly the same time. The time required to produce fading in each dye was as follows:

Carbon BCF Grains	60 hours
Navy Blue 4RCF Supra	60 hours
Tan 3RCF	30 hours
Direct Blue 8RCF	60 hours
Brilliant Green GCF	60 hours

Wash-Fastness Results.--All of the dyes bled into the bleached cotton backing during the Number Three Wash Test. Neither the high temperature nor the normal temperature product bled appreciably more than the other. However, the high temperature product did appear to retain more of its original depth of shade than did the normal temperature product. This would be due to the heavier take-on of dye that we were able to achieve at the higher temperature.

In evaluating the absolute results of the light and wash fastness tests, we must remember that none of the dyeings was after-treated. It is known that sulfur dyes derive some resistance to light and washing from treatment with copper sulfate or acetic acid. After-treatment was not resorted to so that any differences in results could be ascribed directly and purely to the difference in temperatures.

Residual Yarn Strength Results.--Neither the high temperature product nor the normal temperature product appeared to lose any significant measure of strength after being dyed. See Table 31 for detailed results. As had been pointed out earlier, the yarn was very irregular in strength. Though Table 31 shows some increase in strength, it is not safe to assume that such was the actual case. This must be ascribed to the inherent variation in the yarn.

CHAPTER V

CONCLUSIONS

All of the remarks that follow, until otherwise qualified, must be applied strictly to the five dyes employed in this investigation.

High temperatures can be used successfully and profitably to apply the sulfur dye on cotton yarn. A one-third saving in time and an increase in exhaustion of from 5.0 to 34.2 per cent can be had concurrently by using this method. This saving in time refers solely to the actual dyeing cycle only. The resulting dyed products are, in every way, as good as those of the normal temperature process. Neither the dye nor the yarn suffers significantly from exposure to the higher temperature.

Since a one-third saving in time and an increase in exhaustion were experienced concurrently, it must be assumed that an exhaustion equal to that of the normal temperature process can be achieved with an even greater saving in time. The corresponding high temperature dyeing time, of course, would have to be determined empirically for each dye.

Though the qualitative results of this work may, in some measure, be an indication of the behavior to be expected of the remainder of the dyes in this class, the quantitative

results should not be taken as either criteria or limits of performance for the class as a whole. There is no reason to assume that either the best or the worst performing member of this class was used in this experiment. The range of performances of the dyes used is so wide as not to preclude the possibility that one or more members of the class will not perform successfully at the higher temperature. By the same token, it is not impossible that there is one or more members which will be superior to any of the dyes used.

CHAPTER VI

RECOMMENDATIONS

Investigation into the behavior of a small group of dyes under special conditions is valuable only in determining the possible modes of behavior that may be expected of the whole class to which the dyes belong.

It has been shown only that some sulfur dyes can be used successfully at a high temperature. Whether all sulfur dyes will behave similarly remains to be determined.

Before the dyeing industry can proceed to use sulfur dyes at a high temperature, it should be equipped with empirical information on which of the dyes can be so used and on the best procedures for applying them. The only authoritative sources for this data are the dyestuff manufacturers.

Therefore, it is recommended that the dyestuff manufacturers collect such information and make it available to the dyeing industry so that it can take advantage of the economies and other benefits that may be realized from the use of high temperatures.

THE PROBLEM

INTRODUCTION

The purpose of this study is to investigate the effect of the introduction of the new curriculum on the learning outcomes of the students in the field of mathematics. The study was conducted in a secondary school in the city of Istanbul, Turkey. The sample consisted of 100 students in the 8th grade. The data were collected through a questionnaire and a test. The results of the study show that the introduction of the new curriculum had a positive effect on the learning outcomes of the students. The students who were taught with the new curriculum performed better than those who were taught with the old curriculum. The results also show that the students who were taught with the new curriculum were more motivated and more interested in learning mathematics. The study suggests that the new curriculum should be implemented in all secondary schools in Turkey. The study also suggests that the teachers should be trained to use the new curriculum effectively. The study is limited to the field of mathematics and the 8th grade. Further studies should be conducted in other fields and grades.

APPENDIX

Table 8. Yarn Number of Scoured, Undyed Cotton Yarn

Sample Number	Weight in Grains of 120 Yards	Yarn Number
1	57.8	17.31
2	61.5	16.25
3	65.5	15.25
4	61.5	16.25
5	63.8	15.65
6	63.9	15.64
7	59.2	16.89
8	68.3	14.63
9	59.1	17.21
10	61.6	16.23
11	65.6	15.32
12	61.7	16.21
13	64.0	15.61
14	64.0	15.61
15	59.8	16.72
16	68.6	14.59
17	57.9	17.29
18	61.4	16.27
19	65.4	15.28
20	61.3	16.29
21	63.7	15.69
22	63.8	15.66
23	59.1	16.91
24	68.2	14.67
25	59.7	16.77
Total		400.10
Average		16.0

**Table 9. Twist of Scoured, Undyed Cotton Yarn
in Turns per Inch**

Direction of Twist: "Z"

Sample Number	Turns per Inch
1	18.10
2	17.50
3	19.75
4	16.80
5	18.10
6	16.50
7	17.25
8	17.60
9	19.60
10	18.95
11	18.20
12	19.85
13	18.55
14	16.50
15	18.80
Total	271.95
Average	18.10

Land and water resources - resources for the future - 18. 1980

Land and water resources

18. 1980 - 1980 - 1980

Land resources	Water resources
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**Table 10. Single Strand Breaking Strength of Scoured,
Undyed Cotton Yarn**

Sample Number	Strength (Pounds)	Sample Number	Strength (Pounds)
1	1.30	21	1.42
2	1.25	22	1.42
3	1.25	23	1.52
4	1.10	24	1.62
5	1.13	25	1.54
6	1.20	26	1.10
7	1.08	27	1.00
8	1.02	28	0.90
9	1.20	29	0.96
10	1.04	30	0.92
11	1.14	31	1.14
12	1.12	32	1.10
13	1.00	33	1.14
14	1.00	34	1.20
15	0.96	35	1.18
16	1.20	36	1.36
17	1.00	37	1.14
18	0.92	38	1.10
19	1.22	39	1.00
20	1.12	40	0.92
Total			45.99
Average			1.15

**Table 11. Light Absorption Percentages for
Sulfogene Carbon HCV Grains**

Value of Monochromatic Filter (millimicrons)	Color	Percentage Transmission of Light	Percentage Absorption of Light
390	Violet	7.0 %	93.0 %
440	Blue	12.3	87.7
465	Blue	14.3	85.7
490	Green	15.6	84.4
515	Green	15.5	84.5
550	Green	14.7	85.3
575	Amber	13.1	86.9
595	Orange	14.0	86.0
620	Red	13.5	86.5
640	Red	12.4	87.6
660	Red	12.0	88.0

Composition of Solution:

1 gram of dye
 1 gram of sodium carbonate
 2 grams of crystalline sodium sulfide
 2 grams of sodium chloride
 Sufficient tap water to make one liter
 of solution

The above solution was then diluted to yield a concentration of one-tenth of a gram of dye per liter of solution.

**Table 12. Light Absorption Percentages for
Sulfogene Navy Blue 4RCF Supra**

Value of Monochromatic Filter (millimicrons)	Color	Percentage Transmission of Light	Percentage Absorption of Light
390	Violet	55.8 %	44.2 %
440	Blue	59.4	40.6
465	Blue	54.6	45.4
490	Green	39.7	60.3
515	Green	31.4	68.6
550	Green	21.3	78.5
575	Amber	28.0	72.0
595	Orange	32.6	67.4
620	Red	36.4	63.6
640	Red	44.1	55.9
660	Red	49.7	50.3

Composition of Solution:

1 gram of dye
 1 gram of sodium carbonate
 4 grams of crystalline sodium sulfide
 2 grams of sodium chloride
 Sufficient tap water to make one liter
 of solution

The above solution was then diluted to yield a concentration of five hundredths of a gram of dye per liter of solution.

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**Table 13. Light absorption Percentages for
Sulfogene Tan 2RCP**

Value of Monochromatic Filters (millimicrons)	Color	Percentage Transmission of Light	Percentage Absorption of Light
390	Violet	36.9 %	63.1 %
440	Blue	39.8	60.2
465	Blue	48.3	51.7
490	Green	57.1	42.9
515	Green	61.8	38.2
550	Green	80.4	19.6
575	Amber	91.3	8.7
595	Orange	94.6	5.4
620	Red	96.0	4.0
640	Red	96.8	3.2
660	Red	97.2	2.8

Composition of Solution:

1 gram of dye
 1 gram of sodium carbonate
 4 grams of crystalline sodium sulfide
 2 grams of sodium chloride
 Sufficient tap water to make one liter
 of solution

The above solution was then diluted to yield a concentration of five hundredths of a gram of dye per liter of solution.

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Paragraph Number	Paragraph Number	Paragraph Number	Paragraph Number
1.1.1	1.1.2	1.1.3	1.1.4
1.1.5	1.1.6	1.1.7	1.1.8
1.1.9	1.1.10	1.1.11	1.1.12
1.1.13	1.1.14	1.1.15	1.1.16
1.1.17	1.1.18	1.1.19	1.1.20
1.1.21	1.1.22	1.1.23	1.1.24
1.1.25	1.1.26	1.1.27	1.1.28
1.1.29	1.1.30	1.1.31	1.1.32
1.1.33	1.1.34	1.1.35	1.1.36
1.1.37	1.1.38	1.1.39	1.1.40
1.1.41	1.1.42	1.1.43	1.1.44
1.1.45	1.1.46	1.1.47	1.1.48
1.1.49	1.1.50	1.1.51	1.1.52
1.1.53	1.1.54	1.1.55	1.1.56
1.1.57	1.1.58	1.1.59	1.1.60
1.1.61	1.1.62	1.1.63	1.1.64
1.1.65	1.1.66	1.1.67	1.1.68
1.1.69	1.1.70	1.1.71	1.1.72
1.1.73	1.1.74	1.1.75	1.1.76
1.1.77	1.1.78	1.1.79	1.1.80
1.1.81	1.1.82	1.1.83	1.1.84
1.1.85	1.1.86	1.1.87	1.1.88
1.1.89	1.1.90	1.1.91	1.1.92
1.1.93	1.1.94	1.1.95	1.1.96
1.1.97	1.1.98	1.1.99	1.1.100

Paragraph 1.1.100

Paragraph 1.1.100

Paragraph 1.1.100

**Table 14. Light Absorption Percentages for
Sulfogene Direct Blue BACF Conc. 200%**

Value of Monochromatic Filter (millimicrons)	Color	Percentage Transmission of Light	Percentage Absorption of Light
390	Violet	48.9 %	51.1 %
440	Blue	54.7	45.3
466	Blue	53.4	46.6
490	Green	45.1	54.9
515	Green	39.7	60.3
550	Green	33.1	66.9
575	Amber	36.9	63.1
595	Orange	40.0	60.0
620	Red	42.7	57.3
640	Red	47.4	52.6
660	Red	51.3	48.7

Composition of Solution:

1 gram of dye
 1 gram of sodium carbonate
 3 grams of crystalline sodium sulfide
 2 grams of sodium chloride
 Sufficient tap water to make one liter
 of solution

The above solution was then diluted to yield a concentration of five hundredths of a gram of dye per liter of solution.

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EXPERIMENTAL TEMPERATURE KELVIN	EXPERIMENTAL PRESSURE ATMOSPHERES	WAVELENGTH MICRONS	WAVELENGTH CENTIMETERS
4.2	0.001	1000	0.1
4.2	0.001	1000	0.1
4.2	0.001	1000	0.1
4.2	0.001	1000	0.1
4.2	0.001	1000	0.1
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**Table 15. Light Absorption Percentages for Sulfogene
Brilliant Green GCF Extra Conc. 150%**

Value of Monochromatic Filter (millimicrons)	Color	Percentage Transmission of Light	Percentage Absorption of Light
390	Violet	61.6 %	38.4 %
440	Blue	73.6	26.2
465	Blue	79.7	20.3
490	Green	81.4	18.6
515	Green	80.0	20.0
550	Green	67.7	32.3
575	Amber	55.4	44.6
595	Orange	52.0	48.0
620	Red	52.4	47.6
640	Red	55.5	44.5
660	Red	58.5	41.5

Composition of Solution:

1 gram of dye
 1 gram of sodium carbonate
 1 gram of crystalline sodium sulfide
 2 grams of sodium chloride
 Sufficient tap water to make one liter
 of solution

The above solution was then diluted to yield a concentration of five hundredths of a gram of dye per liter of solution.

TABLE 1. *Estimated and observed annualized rates of return on U.S. government bonds, 1950-1990*

Estimated annualized rate of return	Observed annualized rate of return	Ratio	Size of sample (number of years)
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40
1.10	1.10	1.00	40

Source: U.S. Treasury Department.

TABLE 2. *Estimated and observed annualized rates of return on U.S. government bonds, 1950-1990*

Estimated and observed annualized rates of return on U.S. government bonds, 1950-1990. The estimated rates are based on the observed rates and the estimated rates are based on the observed rates.

**Table 16. Light Transmission Percentages for
Sulfogene Carbon HCF Grains**

Concentration in Grams per Liter	Percentage Transmission
0.01	78.6
0.02	59.6
0.03	46.3
0.04	36.4
0.05	27.6

Composition of Solution:

1 gram of dye
1 gram of sodium carbonate
2 grams of crystalline sodium sulfide
2 grams of sodium chloride
Sufficient tap water to make one liter
of solution

The solution was then diluted to yield the working concentrations listed above.

Monochromatic Filter Used: Violet - 390 millimicrons

**Scale Ratio Used: 15 Galvanometer Graduations to
10 Transmission Dial Graduations**

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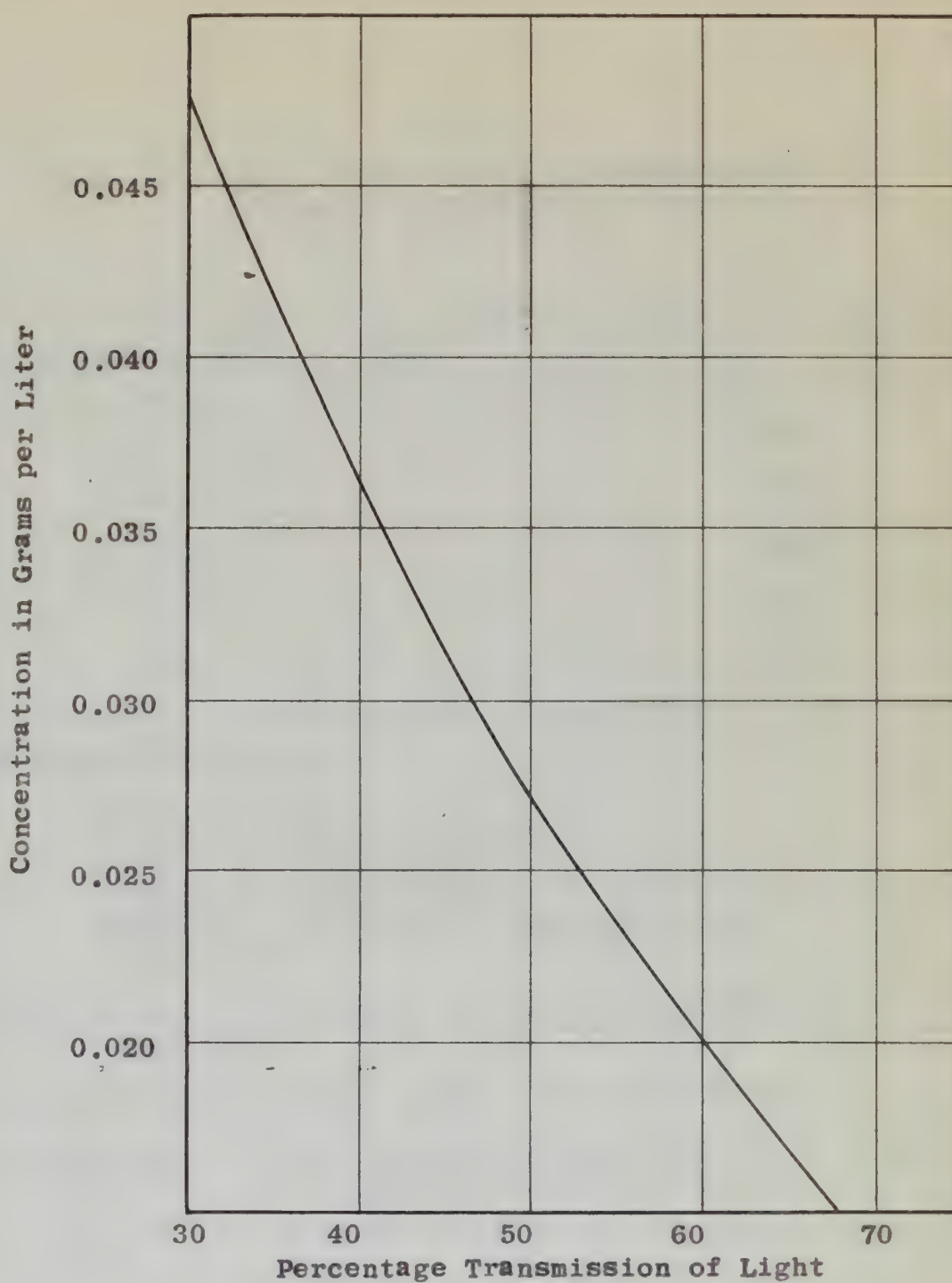


Fig. 4 Sulfolene Carbon HCF Grains
Concentration vs. Percentage
Light Transmission.

**Table 17. Light Transmission Percentages for
Sulfogene Navy Blue 4RCF Supra**

Concentration in Grams per Liter	Percentage Transmission
0.01	73.1
0.02	54.0
0.03	39.5
0.04	28.9
0.05	21.5

Composition of Solution:

1 gram of dye
1 gram of sodium carbonate
4 grams of crystalline sodium sulfide
2 grams of sodium chloride
Sufficient tap water to make one liter
of solution

The solution was then diluted to yield the working concentrations listed above.

Monochromatic Filter Used: Green - 550 millimicrons

**Scale Ratio Used: 15 Galvanometer Graduations to
10 Transmission Dial Graduations**

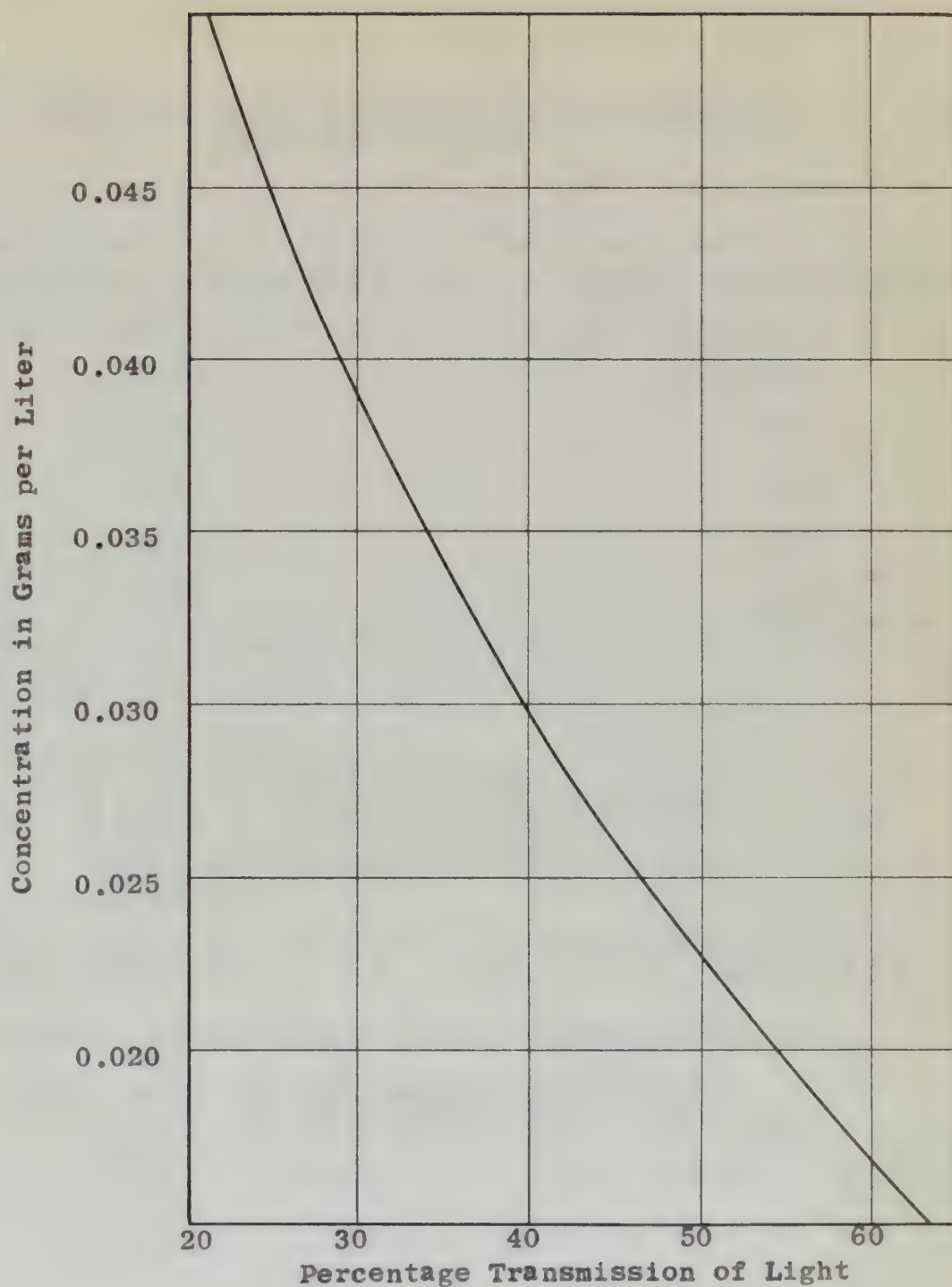


Fig. 5 Sulfogene Navy Blue 4RCF Supra
Concentration vs. Percentage
Transmission of Light

**Table 18. Light Transmission Percentages for
Sulfogene Tan 2RCP**

Concentration in Grams per Liter	Percentage Transmission
0.01	83.1
0.02	68.6
0.03	56.1
0.04	45.5
0.05	36.0

Composition of Solution:

1 gram of dye
1 gram of sodium carbonate
4 grams of crystalline sodium sulfide
2 grams of sodium chloride
Sufficient tap water to make one liter
of solution

The solution was then diluted to yield the working concentrations listed above.

Monochromatic Filter Used: Violet - 390 millimicrons

Scale Ratio Used: 15 Galvanometer Graduations to
10 Transmission Dial Graduations

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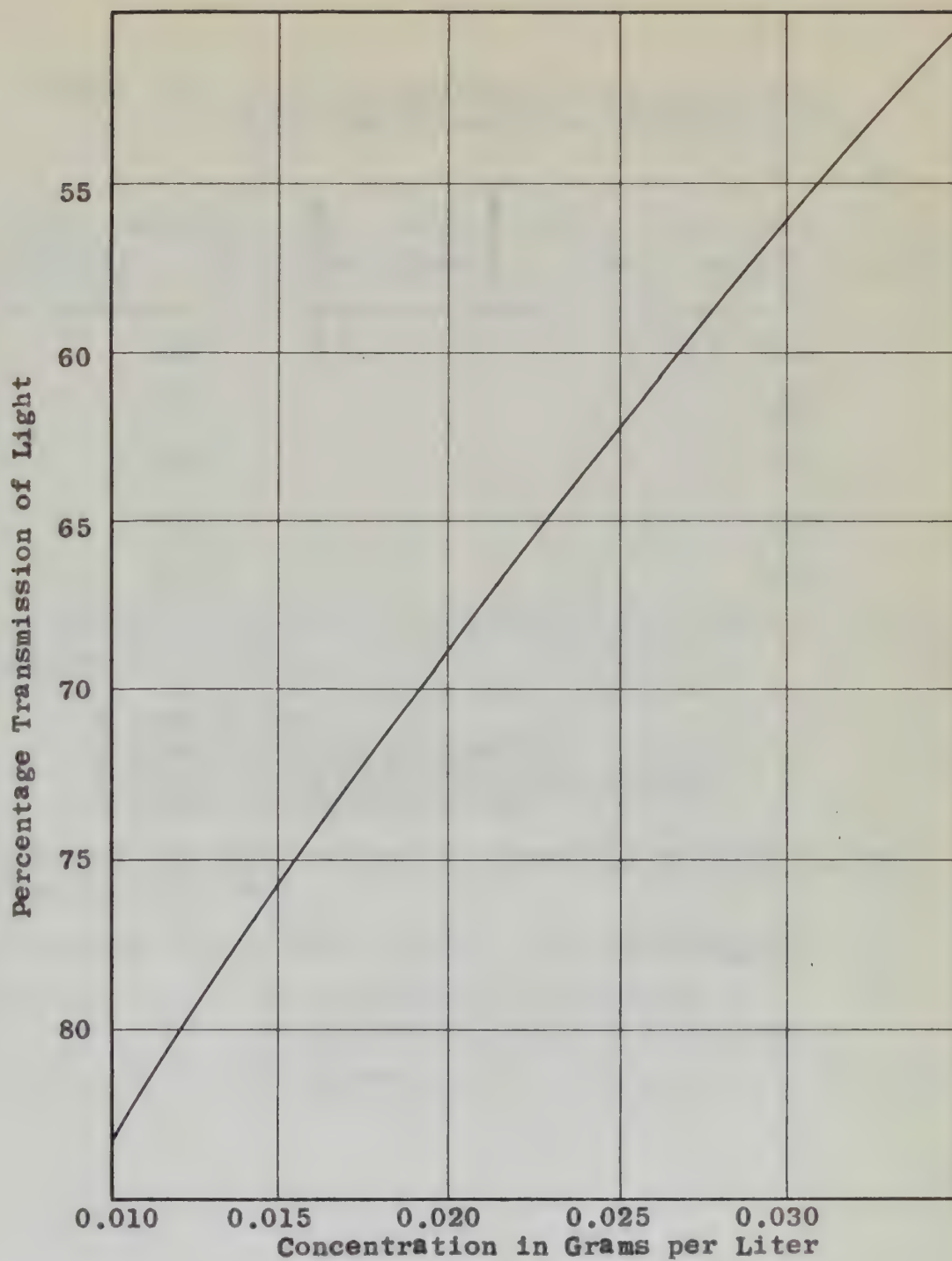


Fig. 6 Sulfolene Tan 2RCF
Concentration vs. Percentage
Transmission of Light

**Table 19. Light Transmission Percentages for
Sulfogene Direct Blue BRCF Conc. 200%**

Concentration in Grams per Liter	Percentage Transmission
0.01	79.2
0.02	64.0
0.03	51.2
0.04	41.0
0.05	33.1

Composition of Solution:

1 gram of dye
1 gram of sodium carbonate
3 grams of crystalline sodium sulfide
2 grams of sodium chloride

The solution was then diluted to yield the working concentrations listed above.

Monochromatic Filter Used: Green - 550 millimicrons

**Scale Ratio Used: 15 Galvanometer Graduations to
10 Transmission Dial Graduations**

and approved accounts from 1914 to 1915
and 1916 to 1917 inclusive

Account Number	Amount
1000	100.00
1001	100.00
1002	100.00
1003	100.00
1004	100.00

Approved by the Board

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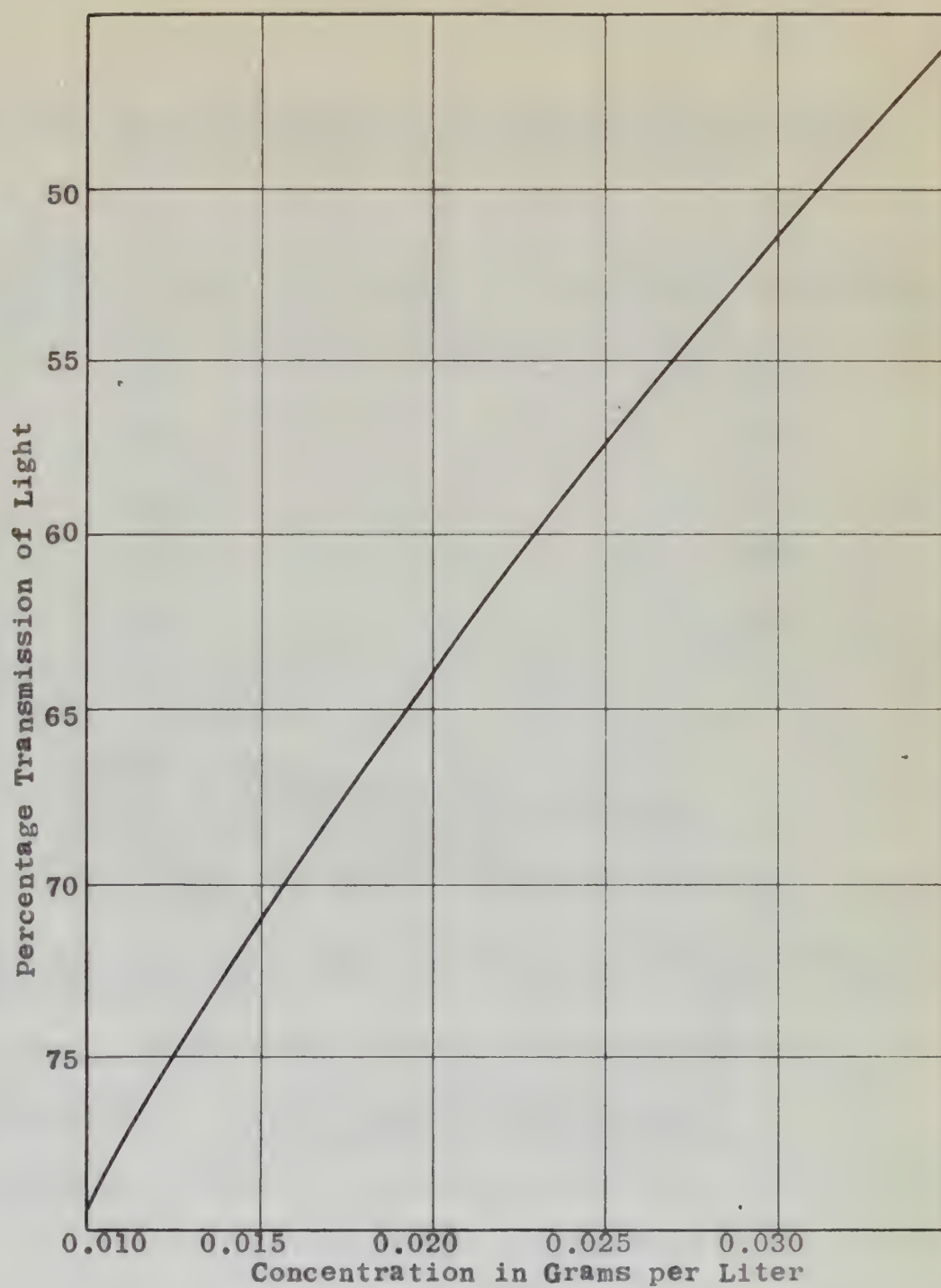


Fig. 7 Sulfochrome Direct Blue BRCF Conc. 200%
Concentration vs. Percentage
Transmission of Light

**Table 20. Light Transmission Percentages for Sulfogens
Brilliant Green GCF Extra Conc. 150%**

Concentration in Grams per Liter	Percentage Transmission
0.01	88.0
0.02	77.1
0.03	67.5
0.04	58.9
0.05	51.5

Composition of Solution:

1 gram of dye
1 gram of sodium carbonate
1 gram of crystalline sodium sulfide
2 grams of sodium chloride
Sufficient tap water to make one liter
of solution

The solution was then diluted to yield the working concentrations listed above.

Monochromatic Filter Used: Orange - 595 millimicrons

Scale Ratio Used: 15 Galvanometer Graduations to
10 Transmission Dial Graduations

TABLE 1. Summary of the results of the analysis of variance for the effect of the treatment on the response of the subjects to the treatment.

Source of variation		Sum of squares	
Between groups		Within groups	
1.00	1.00	1.00	1.00
2.00	2.00	2.00	2.00
3.00	3.00	3.00	3.00
4.00	4.00	4.00	4.00
5.00	5.00	5.00	5.00

TABLE 2. Summary of the results of the analysis of variance for the effect of the treatment on the response of the subjects to the treatment.

Source of variation		Sum of squares	
Between groups		Within groups	
1.00	1.00	1.00	1.00
2.00	2.00	2.00	2.00
3.00	3.00	3.00	3.00
4.00	4.00	4.00	4.00
5.00	5.00	5.00	5.00

TABLE 3. Summary of the results of the analysis of variance for the effect of the treatment on the response of the subjects to the treatment.

Source of variation		Sum of squares	
Between groups		Within groups	
1.00	1.00	1.00	1.00
2.00	2.00	2.00	2.00
3.00	3.00	3.00	3.00
4.00	4.00	4.00	4.00
5.00	5.00	5.00	5.00

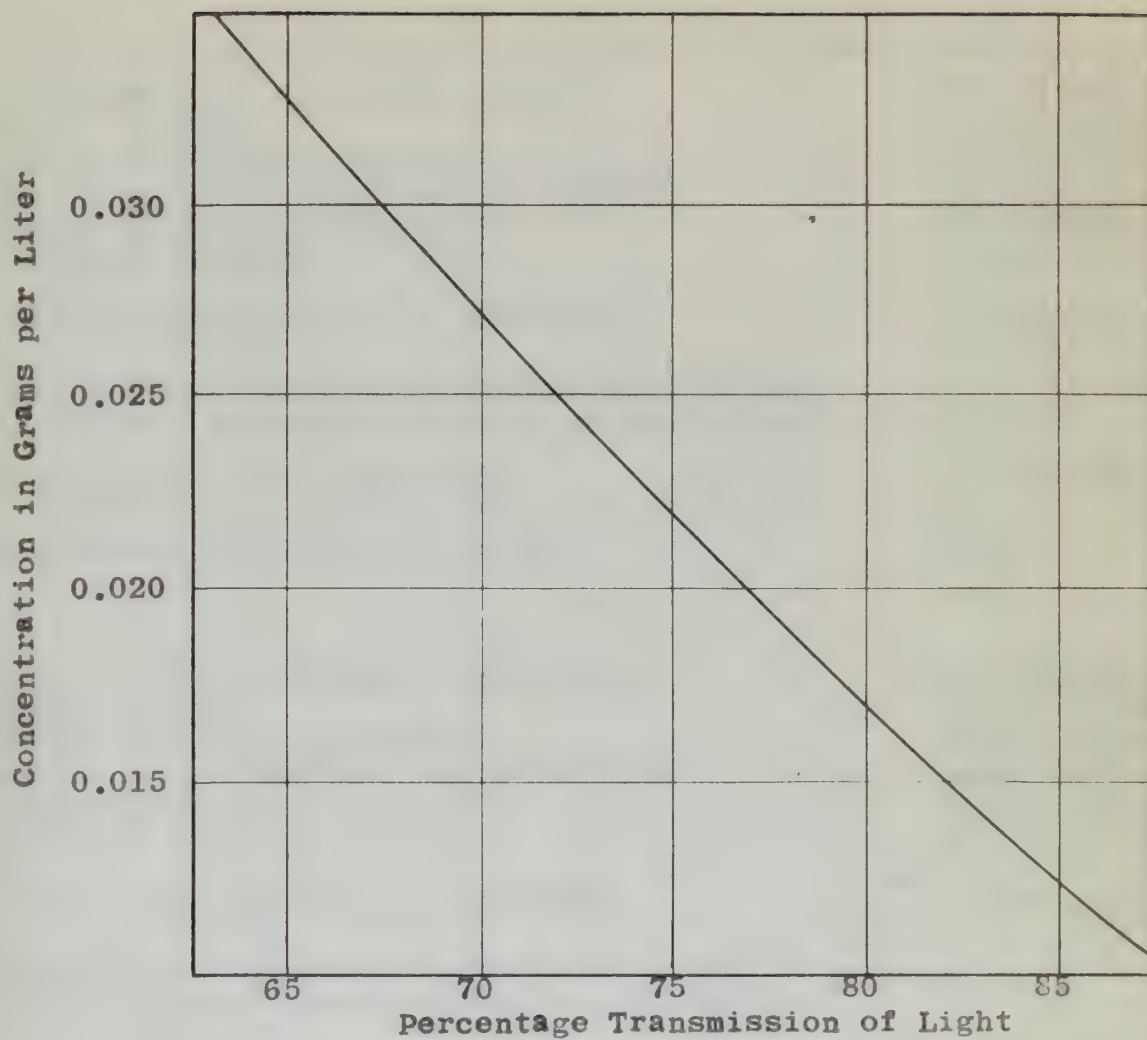


Fig. 8 Sulfogene Brilliant Green GCF Extra
Conc. 150% Concentration vs. Per-
centage Transmission of Light

Table 31. Dyebath Exhaustion for Sulfogene Carbon HCF Grains at 190 Degrees, Fahrenheit, for Sixty Minutes

Weight of Yarn (package Number 1)	438.00 grams
Weight of Dye	42.60 grams
Weight of Sodium Carbonate	42.60 grams
Weight of Crystalline Sodium Sulfide	85.20 grams
Weight of Sodium Chloride	85.20 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.04 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	60.9 %
Corresponding Concentration	1.92 gms/L
Percentage Exhaustion of Dyebath	36.8 %
Weight of Yarn (package Number 14)	438.00 grams
Weight of Dye	43.80 grams
Weight of Sodium Carbonate	43.80 grams
Weight of Crystalline Sodium Sulfide	87.60 grams
Weight of Sodium Chloride	87.60 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.13 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	61.0 %
Corresponding Concentration	1.91 gms/L
Percentage Exhaustion of Dyebath	39.0 %
Average Exhaustion of Dyebaths	37.9 %

**Table 22. Dyebath Exhaustion for Sulfogene Carbon NCF
Grains at High Temperature**

**Time of Dyeing: Forty minutes (including 15 minutes at
250 degrees, F.)**

Weight of Yarn (Package Number 2)	414.750 grams
Weight of Dye	41.475 grams
Weight of Sodium Carbonate	41.475 grams
Weight of Crystalline Sodium Sulfide	82.950 grams
Weight of Sodium Chloride	82.950 grams
Volume of Dyebath	14.000 liters
 Initial Concentration of Dyebath	 2.96 gms/L
 Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	 65.2 %
 Corresponding Concentration	 1.85 gms/L
 Percentage Exhaustion of Dyebath	 44.3 %
Weight of Yarn (Package Number 12)	436.70 grams
Weight of Dye	43.67 grams
Weight of Sodium Carbonate	43.67 grams
Weight of Crystalline Sodium Sulfide	87.34 grams
Weight of Sodium Chloride	87.34 grams
Volume of Dyebath	14.00 liters
 Initial Concentration of Dyebath	 3.12 gms/L
 Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	 64.3 %
 Corresponding Concentration	 1.71 gms/L
 Percentage Exhaustion of Dyebath	 45.2 %
Average Exhaustion of Dyebaths	44.7 %

**Table 23. Dyebath Exhaustion for Sulfogene Navy Blue 4RCF
Supra at 190 Degrees, Fahrenheit, for Sixty
Minutes**

Weight of Yarn (Package Number 3)	426.40 grams
Weight of Dye	42.64 grams
Weight of Sodium Carbonate	42.64 grams
Weight of Crystalline Sodium Sulfide	170.56 grams
Weight of Sodium Chloride	85.28 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.046 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	49.7 %
Corresponding Concentration	2.275 gms/L
Percentage Exhaustion of Dyebath	25.3 %
Weight of Yarn (Package Number 15)	456.00 grams
Weight of Dye	45.60 grams
Weight of Sodium Carbonate	45.60 grams
Weight of Crystalline Sodium Sulfide	182.40 grams
Weight of Sodium Chloride	91.20 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.257 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	47.9 %
Corresponding Concentration	2.388 gms/L
Percentage Exhaustion of Dyebath	26.7 %
Average Exhaustion of Dyebaths	26.0 %

THESE ARE THE RESULTS OF THE ANALYSIS OF THE DATA
 FOR THE YEAR 1998. THE RESULTS ARE AS FOLLOWS:

1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	1969	1968	1967	1966	1965	1964	1963	1962	1961	1960	1959	1958	1957	1956	1955	1954	1953	1952	1951	1950	1949	1948	1947	1946	1945	1944	1943	1942	1941	1940	1939	1938	1937	1936	1935	1934	1933	1932	1931	1930	1929	1928	1927	1926	1925	1924	1923	1922	1921	1920	1919	1918	1917	1916	1915	1914	1913	1912	1911	1910	1909	1908	1907	1906	1905	1904	1903	1902	1901	1900	1899	1898	1897	1896	1895	1894	1893	1892	1891	1890	1889	1888	1887	1886	1885	1884	1883	1882	1881	1880	1879	1878	1877	1876	1875	1874	1873	1872	1871	1870	1869	1868	1867	1866	1865	1864	1863	1862	1861	1860	1859	1858	1857	1856	1855	1854	1853	1852	1851	1850	1849	1848	1847	1846	1845	1844	1843	1842	1841	1840	1839	1838	1837	1836	1835	1834	1833	1832	1831	1830	1829	1828	1827	1826	1825	1824	1823	1822	1821	1820	1819	1818	1817	1816	1815	1814	1813	1812	1811	1810	1809	1808	1807	1806	1805	1804	1803	1802	1801	1800	1799	1798	1797	1796	1795	1794	1793	1792	1791	1790	1789	1788	1787	1786	1785	1784	1783	1782	1781	1780	1779	1778	1777	1776	1775	1774	1773	1772	1771	1770	1769	1768	1767	1766	1765	1764	1763	1762	1761	1760	1759	1758	1757	1756	1755	1754	1753	1752	1751	1750	1749	1748	1747	1746	1745	1744	1743	1742	1741	1740	1739	1738	1737	1736	1735	1734	1733	1732	1731	1730	1729	1728	1727	1726	1725	1724	1723	1722	1721	1720	1719	1718	1717	1716	1715	1714	1713	1712	1711	1710	1709	1708	1707	1706	1705	1704	1703	1702	1701	1700	1699	1698	1697	1696	1695	1694	1693	1692	1691	1690	1689	1688	1687	1686	1685	1684	1683	1682	1681	1680	1679	1678	1677	1676	1675	1674	1673	1672	1671	1670	1669	1668	1667	1666	1665	1664	1663	1662	1661	1660	1659	1658	1657	1656	1655	1654	1653	1652	1651	1650	1649	1648	1647	1646	1645	1644	1643	1642	1641	1640	1639	1638	1637	1636	1635	1634	1633	1632	1631	1630	1629	1628	1627	1626	1625	1624	1623	1622	1621	1620	1619	1618	1617	1616	1615	1614	1613	1612	1611	1610	1609	1608	1607	1606	1605	1604	1603	1602	1601	1600	1599	1598	1597	1596	1595	1594	1593	1592	1591	1590	1589	1588	1587	1586	1585	1584	1583	1582	1581	1580	1579	1578	1577	1576	1575	1574	1573	1572	1571	1570	1569	1568	1567	1566	1565	1564	1563	1562	1561	1560	1559	1558	1557	1556	1555	1554	1553	1552	1551	1550	1549	1548	1547	1546	1545	1544	1543	1542	1541	1540	1539	1538	1537	1536	1535	1534	1533	1532	1531	1530	1529	1528	1527	1526	1525	1524	1523	1522	1521	1520	1519	1518	1517	1516	1515	1514	1513	1512	1511	1510	1509	1508	1507	1506	1505	1504	1503	1502	1501	1500	1499	1498	1497	1496	1495	1494	1493	1492	1491	1490	1489	1488	1487	1486	1485	1484	1483	1482	1481	1480	1479	1478	1477	1476	1475	1474	1473	1472	1471	1470	1469	1468	1467	1466	1465	1464	1463	1462	1461	1460	1459	1458	1457	1456	1455	1454	1453	1452	1451	1450	1449	1448	1447	1446	1445	1444	1443	1442	1441	1440	1439	1438	1437	1436	1435	1434	1433	1432	1431	1430	1429	1428	1427	1426	1425	1424	1423	1422	1421	1420	1419	1418	1417	1416	1415	1414	1413	1412	1411	1410	1409	1408	1407	1406	1405	1404	1403	1402	1401	1400	1399	1398	1397	1396	1395	1394	1393	1392	1391	1390	1389	1388	1387	1386	1385	1384	1383	1382	1381	1380	1379	1378	1377	1376	1375	1374	1373	1372	1371	1370	1369	1368	1367	1366	1365	1364	1363	1362	1361	1360	1359	1358	1357	1356	1355	1354	1353	1352	1351	1350	1349	1348	1347	1346	1345	1344	1343	1342	1341	1340	1339	1338	1337	1336	1335	1334	1333	1332	1331	1330	1329	1328	1327	1326	1325	1324	1323	1322	1321	1320	1319	1318	1317	1316	1315	1314	1313	1312	1311	1310	1309	1308	1307	1306	1305	1304	1303	1302	1301	1300	1299	1298	1297	1296	1295	1294	1293	1292	1291	1290	1289	1288	1287	1286	1285	1284	1283	1282	1281	1280	1279	1278	1277	1276	1275	1274	1273	1272	1271	1270	1269	1268	1267	1266	1265	1264	1263	1262	1261	1260	1259	1258	1257	1256	1255	1254	1253	1252	1251	1250	1249	1248	1247	1246	1245	1244	1243	1242	1241	1240	1239	1238	1237	1236	1235	1234	1233	1232	1231	1230	1229	1228	1227	1226	1225	1224	1223	1222	1221	1220	1219	1218	1217	1216	1215	1214	1213	1212	1211	1210	1209	1208	1207	1206	1205	1204	1203	1202	1201	1200	1199	1198	1197	1196	1195	1194	1193	1192	1191	1190	1189	1188	1187	1186	1185	1184	1183	1182	1181	1180	1179	1178	1177	1176	1175	1174	1173	1172	1171	1170	1169	1168	1167	1166	1165	1164	1163	1162	1161	1160	1159	1158	1157	1156	1155	1154	1153	1152	1151	1150	1149	1148	1147	1146	1145	1144	1143	1142	1141	1140	1139	1138	1137	1136	1135	1134	1133	1132	1131	1130	1129	1128	1127	1126	1125	1124	1123	1122	1121	1120	1119	1118	1117	1116	1115	1114	1113	1112	1111	1110	1109	1108	1107	1106	1105	1104	1103	1102	1101	1100	1099	1098	1097	1096	1095	1094	1093	1092	1091	1090	1089	1088	1087	1086	1085	1084	1083	1082	1081	1080	1079	1078	1077	1076	1075	1074	1073	1072	1071	1070	1069	1068	1067	1066	1065	1064	1063	1062	1061	1060	1059	1058	1057	1056	1055	1054	1053	1052	1051	1050	1049	1048	1047	1046	1045	1044	1043	1042	1041	1040	1039	1038	1037	1036	1035	1034	1033	1032	1031	1030	1029	1028	1027	1026	1025	1024	1023	1022	1021	1020	1019	1018	1017	1016	1015	1014	1013	1012	1011	1010	1009	1008	1007	1006	1005	1004	1003	1002	1001	1000	999	998	997	996	995	994	993	992	991	990	989	988	987	986	985	984	983	982	981	980	979	978	977	976	975	974	973	972	971	970	969	968	967	966	965	964	963	962	961	960	959	958	957	956	955	954	953	952	951	950	949	948	947	946	945	944	943	942	941	940	939	938	937	936	935	934	933	932	931	930	929	928	927	926	925	924	923	922	921	920	919	918	917	916	915	914	913	912	911	910	909	908	907	906	905	904	903	902	901	900	899	898	897	896	895	894	893	892	891	890	889	888	887	886	885	884	883	882	881	880	879	878	877	876	875	874	873	872	871	870	869	868	867	866	865	864	863	862	861	860	859	858	857	856	855	854	853	852	851	850	849	848	847	846	845	844	843	842	841	840	839	838	837	836	835	834	833	832	831	830	829	828	827	826	825	824	823	822	821	820	819	818	817	816	815	814	813	812	811	810	809	808	807	806	805	804	803	802	801	800	799	798	797	796	795	794	793	792	791	790	789	788	787	786	785	784	783	782	781	780	779	778	777	776	775	774	773	772	771	770	769	768	767	766	765	764	763	762	761	760	759	758	757	756	755	754	753	752	751	750	749	748	747	746	745	744	743	742	741	740	739	738	737	736	735	734	733	732	731	730	729	728	727	726	725	724	723	722	721	720	719	718	717	716	715	714	713	712	711	710	709	708	707	706	705	704	703	702	701	700	699	698	697	696	695	694	693	692	691	690	689	688	687	686	685	684	683	682	681	680	679	678	677	676	675	674	673	672	671	670	669	668	667	666	665	664	663	662	661	660	659	658	657	656	655	654	653	652	651	650	649	648	647	646	645	644	643	642	641	640	639	638	637	636	635	634	633	632	631	630	629	628	627	626	625	624	623	622	621	620	619	618	617	616	615	614	613	612	611	610	609	608	607	606	605	604	603	602	601	600	599	598	597	596	595	594	593	592	591	590	589	5
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**Table 24. Dyebath Exhaustion for Sulfogene Navy Blue 4RCF
Supra at High Temperature**

**Time of Dyeing: Forty minutes (including 15 minutes at
250 degrees, F.)**

Weight of Yarn (Package Number 4)	420.1 grams
Weight of Dye	42.01 grams
Weight of Sodium Carbonate	42.01 grams
Weight of Crystalline Sodium Sulfide	163.04 grams
Weight of Sodium Chloride	84.02 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.001 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	54.8 %
Corresponding Concentration	1.945 gms/L
Percentage Exhaustion of Dyebath	35.2 %
Weight of Yarn (Package Number 16)	440.1 grams
Weight of Dye	44.01 grams
Weight of Sodium Carbonate	44.01 grams
Weight of Crystalline Sodium Sulfide	176.04 grams
Weight of Sodium Chloride	88.02 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.144 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	53.0 %
Corresponding Concentration	2.050 gms/L
Percentage Exhaustion of Dyebath	34.5 %
Average Exhaustion of Dyebaths	34.9 %

**Table 25. Dyebath Exhaustion for Sulfogene Tan 2RCF
at 190 Degrees, Fahrenheit, for Sixty Minutes**

Weight of Yarn (Package Number 5)	426.2 grams
Weight of Dye	42.62 grams
Weight of Sodium Carbonate	42.62 grams
Weight of Crystalline Sodium Sulfide	170.48 grams
Weight of Sodium Chloride	85.24 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.044 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	69.5 %
Corresponding Concentration	1.945 gms/L
Percentage Exhaustion of Dyebath	36.1 %
Weight of Yarn (Package Number 17)	446.1 grams
Weight of Dye	44.61 grams
Weight of Sodium Carbonate	44.61 grams
Weight of Crystalline Sodium Sulfide	178.44 grams
Weight of Sodium Chloride	89.22 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.186 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	67.5 %
Corresponding Concentration	2.113 gms/L
Percentage Exhaustion of Dyebath	34.3 %
Average Exhaustion of Dyebaths	35.2 %

**Table 26. Dyebath Exhaustion for Sulfogene Tan 2RCP
at High Temperature**

**Time of Dyeing: Forty minutes (including 15 minutes
at 250 degrees, F.)**

Weight of Yarn (Package Number 6)	421.8 grams
Weight of Dye	42.18 grams
Weight of Sodium Carbonate	42.18 grams
Weight of Crystalline Sodium Sulfide	168.72 grams
Weight of Sodium Chloride	84.36 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.013 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	74.0 %
Corresponding Concentration	1.803 gms/L
Percentage Exhaustion of Dyebath	40.8 %
Weight of Yarn (Package Number 18)	432.0 grams
Weight of Dye	43.2 grams
Weight of Sodium Carbonate	43.2 grams
Weight of Crystalline Sodium Sulfide	172.8 grams
Weight of Sodium Chloride	86.4 grams
Volume of Dyebath	14.0 liters
Initial Concentration of Dyebath	3.066 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	73.6 %
Corresponding Concentration	1.850 gms/L
Percentage Exhaustion of Dyebath	40.5 %
Average Exhaustion of Dyebaths	40.65 %

Table 27. Dyebath Exhaustion for Sulfogene Direct Blue BRCF Conc. 200%, at 190 Degrees, Fahrenheit, for Sixty Minutes

Weight of Yarn (Package Number 7)	405.0	grams
Weight of Dye	40.5	grams
Weight of Sodium Carbonate	40.5	grams
Weight of Crystalline Sodium Sulfide	121.5	grams
Weight of Sodium Chloride	81.0	grams
Volume of Dyebath	14.0	liters
Initial Concentration of Dyebath	2.8929	gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	63.4	%
Corresponding Concentration	2.0375	gms/L
Percentage Exhaustion of Dyebath	29.6	%
Weight of Yarn (Package Number 19)	407.9	grams
Weight of Dye	40.79	grams
Weight of Sodium Carbonate	40.79	grams
Weight of Crystalline Sodium Sulfide	122.37	grams
Weight of Sodium Chloride	81.55	grams
Volume of Dyebath	14.00	liters
Initial Concentration of Dyebath	2.6136	gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	65.0	%
Corresponding Concentration	1.9275	gms/L
Percentage Exhaustion of Dyebath	33.8	%
Average Exhaustion of Dyebaths	31.7	%

**Table 28. Dyebath Exhaustion for Sulfogens Direct Blue
BACF Conc. 200% at High Temperature**

Weight of Yarn (Package Number 8)	419.8 grams
Weight of Dye	41.98 grams
Weight of Sodium Carbonate	41.98 grams
Weight of Crystalline Sodium Sulfide	125.94 grams
Weight of Sodium Chloride	83.96 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	2.9986 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	64.9 %
Corresponding Concentration	1.9275 gms/L
Percentage Exhaustion of Dyebath	35.7 %
Weight of Yarn (Package Number 20)	458.3 grams
Weight of Dye	45.83 grams
Weight of Sodium Carbonate	45.83 grams
Weight of Crystalline Sodium Sulfide	127.49 grams
Weight of Sodium Chloride	91.66 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.2736 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	62.4 %
Corresponding Concentration	2.1125 gms/L
Percentage Exhaustion of Dyebath	35.5 %
Average Exhaustion of Dyebaths	35.6 %

Table 29. Dyebath Exhaustion for Sulfogene Brilliant Green GCF Extra Conc. 150% at 190 Degrees, Fahrenheit, for Sixty Minutes

Weight of Yarn (Package Number 9)	434.9 grams
Weight of Dye	43.49 grams
Weight of Sodium Carbonate	43.49 grams
Weight of Crystalline Sodium Sulfide	43.49 grams
Weight of Sodium Chloride	86.98 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.1064 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	80.0 %
Corresponding Concentration	1.7125 gms/L
Percentage Exhaustion of Dyebath	44.9 %
Weight of Yarn (Package Number 21)	393.5 grams
Weight of Dye	39.35 grams
Weight of Sodium Carbonate	39.35 grams
Weight of Crystalline Sodium Sulfide	39.35 grams
Weight of Sodium Chloride	78.70 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	2.8107 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	81.0 %
Corresponding Concentration	1.8125 gms/L
Percentage Exhaustion of Dyebath	42.6 %
Average Exhaustion of Dyebaths	43.8 %

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Table 30. Dyebath Exhaustion for Sulfogene Brilliant Green OCF Extra Conc. 150% at High Temperature

Weight of Yarn (Package Number 10)	441.3 grams
Weight of Dye	44.13 grams
Weight of Sodium Carbonate	44.13 grams
Weight of Crystalline Sodium Sulfide	44.13 grams
Weight of Sodium Chloride	88.26 grams
Volume of Dyebath	14.00 liters
Initial Concentration of Dyebath	3.1521 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	79.7 %
Corresponding Concentration	1.7375 gms/L
Percentage Exhaustion of Dyebath	44.9 %
Weight of Yarn (Package Number 22)	427.0 grams
Weight of Dye	42.7 grams
Weight of Sodium Carbonate	42.7 grams
Weight of Crystalline Sodium Sulfide	42.7 grams
Weight of Sodium Chloride	42.7 grams
Volume of Dyebath	14.0 liters
Initial Concentration of Dyebath	3.0500 gms/L
Transmission of Light of Exhausted Dyebath (Diluted to one one-hundredth concentration)	81.0 %
Corresponding Concentration	1.6125 gms/L
Percentage Exhaustion of Dyebath	47.1 %
Average Exhaustion of Dyebaths	46.0 %

Table 31. Comparison of Residual Strengths of Dyed Yarns

Sulfogene Dyes	Normal Temperature	High Temperature
Carbon RCF Grains	Package #1	Package #2
Break-Strength Before Dyeing	1.21 lbs.	1.11 lbs.
Break-Strength After Dyeing	1.06	1.12
Change in Strength	0.15 lb. loss	0.01 lb. gain
Navy Blue 4RCF Supra	Package #3	Package #4
Break-Strength Before Dyeing	1.04 lbs.	1.10 lbs.
Break-Strength After Dyeing	1.11	1.09
Change in Strength	0.07 lb. gain	0.01 lb. loss
Tan 2RCF	Package #5	Package #6
Break-Strength Before Dyeing	1.50 lbs.	0.97 lbs.
Break-Strength After Dyeing	1.06	1.14
Change in Strength	0.44 lb. loss	0.17 lb. gain
Direct Blue BRCF	Package #7	Package #8
Break-Strength Before Dyeing	1.15 lbs.	1.10 lbs.
Break-Strength After Dyeing	1.13	1.29
Change in Strength	0.02 lb. loss	0.19 lb. gain
Brilliant Green GCF	Package #9	Package #10
Break-Strength Before Dyeing	1.06 lbs.	1.11 lbs.
Break-Strength After Dyeing	1.23	1.13
Change in Strength	0.17 lb. gain	0.02 lb. gain

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1. The purpose of this document is to provide information regarding the activities of the [redacted] and the [redacted] in the [redacted] area.

2. The [redacted] has been observed in the [redacted] area, and it is believed that it is engaged in [redacted] activities.

3. The [redacted] is believed to be engaged in [redacted] activities.

4. The [redacted] is believed to be engaged in [redacted] activities, and it is believed that it is engaged in [redacted] activities.

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11. The [redacted] is believed to be engaged in [redacted] activities, and it is believed that it is engaged in [redacted] activities.

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